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Prevalence of *Giardia intestinalis* in Illinois Beavers

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ABSTRACT

The prevalence and spatial distribution of *Giardia intestinalis* was surveyed in beavers (*Castor canadensis* Kuhl) trapped in 5 watersheds in central and southern Illinois. Beavers were tested for the presence of cysts using a fluorescein-labeled antibody test. *Giardia* cysts were detected in 30.8% of 107 beavers sampled. The percentage of *Giardia*-infected beavers was higher than reported in previous studies. Prevalence did not differ between males and females or between adults and juveniles. Differences in prevalence among watersheds were not found, but beavers inhabiting 2 large recreational lakes showed the highest prevalence of infection. Whether beavers serve as initial sources of surface water contamination or as amplifying hosts, this intestinal parasite is likely to become more prevalent in Illinois' waterways as beaver populations increase statewide.

INTRODUCTION

Giardia intestinalis (= *G. lamblia, = G. duodenalis*) is a microscopic protozoan parasite infecting warm-blooded animals, including humans. It is the most common human intestinal parasite in developed countries and giardiasis is the most frequently reported waterborne disease (Schantz, 1991; Thompson et al., 1993). *Giardia* cysts can be transmitted among people via indirect contact with feces (Ormiston et al., 1942) or by sexual activity (Meyers et al., 1977). Rarely, giardiasis can be acquired from pets (Davies and Hibler, 1979). However, most cases occur when humans are exposed to a contaminated water supply (Thompson et al., 1993).

Waterways become contaminated when cysts are introduced via animal feces or human sewage. Beavers (*Castor canadensis* Kuhl) have been identified as an important wildlife host for this parasite to the extent that giardiasis is sometimes referred to as "beaver fever" (Gaydos, 1998). Whether beavers are the original source of contamination or simply amplify existing numbers of cysts, it is clear that they are an important reservoir for this parasite (Thompson et al., 1993).

Although surveys have been conducted to assess the prevalence of *Giardia* in beavers, none have been conducted in Illinois or the southern part of this host's range. Further, we are not aware of any attempt to compare the prevalence of this parasite in beavers inhabiting adjacent watersheds or habitats with different ecological and hydrological characteristics. Therefore, the objectives of this study were to: (1) estimate the prevalence of *G. intestinalis* in beavers of central and southern Illinois, (2) test whether prevalence differs between sexes and age-classes, and (3) survey spatial patterns of *Giardia* in the watersheds of this region.

STUDY AREA

Beavers from 5 watersheds in central and southern Illinois were trapped and examined. This region extended from Champaign Co. in central IL to Jefferson Co. in southern IL. Beavers were collected from the watersheds of the Kaskaskia River, Big Muddy River, Little Wabash River, Embarras River, and Mill Creek. We categorized each animal as inhabiting river, lake, or ditch habitats based on the location of their den or lodge. Many of the beavers inhabiting lakes were trapped in either Rend Lake (Big Muddy watershed) or Lake Shelbyville (Kaskaskia watershed). Both are large recreational reservoirs that are used heavily by campers, boaters and fishermen.

METHODS

We collected beavers at lodges, food caches, and feeding sites during the winter of 2000-2001 using #330 conibear traps. This method of euthanasia meets the guidelines for humane treatment of animals and was approved by Eastern Illinois University's Animal Care and Use Committee. Each animal was dissected and sexed based on reproductive organs (Osborn, 1955). Ages were estimated by removing the 4 cheek teeth (1 premolar and 3 molars) from the left side of the lower jaw and noting the eruption, extent of basal closure, and deposition of cementum annuli on these teeth (Larson and Van Nostrand, 1968).

Samples were collected from the upper 25 cm of the small intestine of each beaver and preserved in 10% formalin. Each sample was suspended in a water solution and smears were made on 2 welled microscope slides. Smears were then air-dried and treated with a *Giardia intestinalis* monoclonal antibody labeled with fluorescein (Waterborne, Inc., New Orleans, LA). Slides were incubated in a humid chamber at room temperature for 40 min. to allow the antibody-antigen reaction to occur. After incubation, we rinsed each slide in a buffer for 60 sec. When the samples were partially dry, a drop of counterstain was added to each slide to stain all non-reactive material. Slides were rinsed again and cover slips were added. We examined each slide using a fluorescence microscope under blue excitation light at 100 X magnification. Using this method, *Giardia* cysts appeared bright green, whereas the background was red. Potential cysts were viewed again at 400 X magnification and their shape and size were compared to cysts on a *Giardia*-positive control sample provided by the manufacturer. Each sample was recorded as being positive or negative for presence of *Giardia*. Chi-square tests were used to test for differences in the prevalence of *Giardia* in males versus females, juveniles ($<$ 2-years old) versus adults ($\geq$ 2-years old), beavers inhabiting the 5 watersheds and 3 habitat types.

RESULTS

Thirty-three (30.8%) of 107 beavers carried *Giardia* cysts, a higher prevalence than the 14-19% typically reported for beavers in Canada and northern states (Table 1). We did not observe differences in prevalence between males and females ($X^2 = 1.62$; 1 df; $P = 0.203$). Thirteen of 52 (25%) females and 20 of 55 males (36%) were infected. Prevalence did not differ between juvenile and adult beavers ($X^2 = 0.51$; 1 df; $P = 0.479$). Of 66 juveniles, 33% tested positive for *Giardia*, whereas 27% of the adults tested positive (Table 2).

We did not find significant differences in prevalence among beavers in the 5 watersheds tested ($X^2 = 4.42$; 4 df; $P = 0.491$). Prevalence was highest in the Big Muddy River watershed (42%) in southern Illinois and the Kaskaskia River watershed (33%) in central Illinois (Table 3). In contrast, we did not find *Giardia* in any of the 6 beavers trapped in the Little Wabash River watershed, however this sample was small. Prevalence was highest among beavers inhabiting the 2 large recreational lakes. Sixty percent (6/10) of beavers from Rend Lake and 56% (9/16) from Lake Shelbyville carried *Giardia* cysts. However, we did not find *Giardia* infections to be more prevalent in lakes relative to ditches and rivers when all locations were considered ($X^2 = 1.63$; 2 df; $P = 0.256$).

DISCUSSION

Few studies have been conducted to determine the role of wild mammals as the source of fecal contamination of surface waters (Tiedemann, 2000). The prevalence of *Giardia* in beavers has been surveyed at several locations in the U.S. and Canada, but none have reported frequencies of infection as high as those that we found in Illinois. Davies and Hibler (1979) reported a prevalence of 18% in Colorado beavers and a similar study in British Columbia found that 14.7% of beavers tested positive for *Giardia* (Issaac-Renton et al., 1987). Researchers in Washington reported that prevalence increased annually over 3 years from 6.3% to 19.0% (Frost et al., 1980). Monzingo and Hibler (1987) reported the highest prevalence (42%) in beavers, however they may have overestimated prevalence because fecal samples were collected from the bottoms of beaver ponds, so multiple samples may have come from the same infected individual (Erlandsen et al., 1990).

Recent evidence suggests that these surveys may have underestimated the true prevalence of *Giardia* infection in beavers because they relied on the visual detection of cysts in fecal samples. Erlandsen et al. (1990) measured prevalence by detecting both trophozoites in fresh mucosal scrapings and cysts in feces. Prevalence was 13.7% using trophozoites, but only 9.2% using cysts. Furthermore, when fecal samples from beavers known to be trophozoite-positive were examined, cysts were detected in only 80.9%. Consequently, these researchers concluded that previous surveys relying on the visual detection of cysts may have underestimated true prevalence. However, they acknowledged that immunofluorescent microscopy, as used in our survey, may provide a more sensitive technique for detecting cysts in feces.

We are not aware of any study that has found the prevalence of *Giardia* infection to differ between the sexes. However, there are contradictory reports as to whether juveniles are more prone to infection than adults. Erlandsen et al. (1990) reported higher prevalence in

juveniles (23.2%) than adults (12.6%). Similarly, juvenile beavers in Washington were more likely to be infected than adults (Frost et al., 1980). However, surveys in Colorado and British Columbia suggested that prevalence does not differ between age-classes (Davies and Hibler, 1979; Issaac-Renton et al., 1987). Beavers live in close-knit colonies, sharing waterways, dens and food supplies. This social structure appears to hasten the transmission of *Giardia* among individuals regardless of sex or age. Our results show that prevalence does not increase with age and increased exposure to cysts, suggesting that beavers may develop some immunity to this parasite with age.

Giardia cysts were common in beavers occupying 4 of the 5 watersheds that we surveyed. All 6 beavers tested from the Little Wabash River were free of infection, but the small sample size warrants further testing in this watershed. Prevalence did not differ among watersheds, but within watersheds tended to be higher among beavers inhabiting the 2 large recreational lakes. This may be due to lower water velocities and hence greater accumulations of cysts in these habitats. Although we did not measure the concentration of cysts in water, we believe that a more important factor may be the intensive use of these lakes by humans. The high prevalence in these lakes is consistent with a previous study suggesting that beavers are more likely to be *Giardia*-infected if they inhabit waterways that receive heavy human use, such as near parks and campgrounds (Suk et al., 1987). Initial contamination of the site may come from human sewage and beavers may serve primarily as amplifying hosts by ingesting a few cysts and then shedding large numbers. Thompson et al. (1993) noted that it has not been possible to prove whether giardiasis in humans is contracted from animals or vice versa. For example, Heitman et al. (2002) examined the prevalence and concentration of cysts in human sewage influent, wildlife and livestock sources in a watershed in Alberta. They found that the prevalence was highest in sewage influent and lowest in wildlife, but the concentration of cysts was highest in cattle feces.

Giardia appears to be ubiquitous in the waterways of central and southern Illinois and its prevalence in beavers is considerably higher than that reported in previous surveys from northern portions of this host's range. This may occur because a warmer climate is more tolerable to *Giardia* and more conducive to its transmission among beavers and other hosts. A previous study found its prevalence in beavers increased in summer and decreased in winter in Colorado (Monzingo and Hibler, 1987). The authors proposed that this pattern was due to seasonal activity levels of beavers. However, we speculate that differences may be due to differential survival and/or concentrations of cysts in cold water. Additional surveys from the southern portions of the beaver's range may shed light on this geographic pattern. Regardless of whether Illinois' beavers serve as initial sources of *Giardia* contamination or as amplifying hosts, this intestinal parasite is likely to become more prevalent in Illinois' waterways as beaver populations increase statewide.

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Table 1. Prevalence of *Giardia intestinalis* in fecal samples of beavers (*Castor canadensis*) reported in previous studies.

Location	*Giardia* prevalence (%)	Citation
Minnesota	13.7	Erlandsen et al. 1990
British Columbia	14.7	Issaac-Renton et al. 1987
Colorado	18.0	Davies and Hibler 1979
Washington	19.0	Frost et al. 1980
Illinois	30.8	this study

Table 2. Age-specific prevalence of *Giardia intestinalis* in beavers from central and southern Illinois.

Age-class	N	*Giardia*-positive
Kits (6-11 mos. old)	44	15 (34.1%)
Yearlings (12-23 mos. old)	22	7 (31.8%)
Two-year olds (24-35 mos. old)	14	4 (28.6%)
Adults (≥36 mos. old)	27	7 (25.9%)
Total	107	33 (30.8%)

Table 3. Prevalence of *Giardia intestinalis* in beavers from 5 watersheds in central and southern Illinois.

Watershed	N	*Giardia*-positive
Big Muddy River	19	8 (42%)
Kaskaskia River	33	11 (33%)
Embarras River	38	11 (29%)
Mill Creek	11	3 (27%)
Little Wabash River	6	0 (0%)