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RESERVOIRS OF *GIARDIA* SPP. IN SOUTHWESTERN ALBERTA

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ABSTRACT: A survey of potential hosts of *Giardia* spp. was carried out during 1982 and 1983 in the Kananaskis Valley and Banff National Park, Alberta, Canada. Diagnosis was based mainly on fecal analysis but a few animals were examined at necropsy and scrapings from the small intestine analyzed. A total of 304 specimens was examined from humans (*Homo sapiens* L.) and a variety of animal species. Cysts and/or trophozoites of *Giardia* were found in 10.5% of the specimens examined. Positive samples were found from 20 of 21 red-backed voles (*Clethrionomys gapperi* Vigors), two of six meadow voles (*Microtus pennsylvanicus* Ord), one of three long-tailed voles (*Microtus longicaudus* Allen), five of 50 deer mice (*Peromyscus maniculatus* Mearns), and two of 58 beavers (*Castor canadensis* Kuhl). Cysts obtained from a beaver were successfully introduced to gerbils (*Meriones unguiculatus* Milne-Edwards) and the trophozoites obtained were cultured in vitro.

INTRODUCTION

Epidemics of giardiasis have been experienced in Alberta several times over the past few years in communities such as Banff, Canmore, Morley, and Edmonton. Other municipalities in North America, particularly in the western United States (Davies and Hibler, 1979), have had similar experiences. *Giardia* infections are usually transmitted by the fecal-oral route but waterborne epidemics are not uncommon. Waterborne transmission of giardiasis occurs most commonly when municipalities rely upon chlorination alone for drinking water treatment and neglect the pre-treatment steps of coagulation and filtration (Craun, 1979). In back country areas, campers and hikers are at risk because of their reliance on surface water for drinking supplies and inadequate sanitation facilities.

The introduction of *Giardia* cysts to water may occur from both human and animal sources (Davies and Hibler, 1979). Cysts from humans are infective to beaver (Davies and Hibler, 1979; Dykes et al., 1980) and dogs (Hewlett et al., 1982). Davies and Hibler (1979) also found that laboratory rats (*Rattus norvegicus* Berkenhout), gerbils, guinea pigs (*Cavia porcellus* Waterhouse), raccoons (*Procyon lotor* L.), bighorn × mouflon sheep (*Ovis canadensis* Shaw × *O. musimon* Pallas) and pronghorn (*Antilocapra americana* Ord) could be infected with *Giardia* from human sources. The potential therefore exists for humans and animals to infect each other through contact in the environment and through waterborne transmission.

This study was conducted in Banff National Park and the Kananaskis Valley located in southwestern Alberta, Canada (approximate latitude and longitude: 51°00′N, 115°05′W), to gain information on the infection rates among humans and animals in a heavily used recreation area in Alberta. The Banff area has been used for outdoor recreational purposes for many years and the Kananaskis Valley has been developed recently by the Alberta Government as an alternative recreational area in the East Slopes of the Rocky Mountains. Outbreaks of giardiasis have been reported from Banff as recently as 1982 (Wilson et al., 1982) and isolated cases have occurred in the Kananaskis Valley. Drinking water was suspected as the source of infection in all cases although cysts have not

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TABLE 1. Prevalence of infection by *Giardia* spp. in various species of wildlife in Banff National Park and in the Kananaskis Valley, Alberta.

Common name	Scientific name	# Positive/total
Red-backed vole	*Clethrionomys gapperi* Vigors	20/21
Meadow vole	*Microtus pennsylvanicus* Ord	2/6
Deer mouse	*Peromyscus maniculatus* Mearns	5/50
Long-tailed vole	*Microtus longicaudus* Allen	1/3
Beaver	*Castor canadensis* Kuhl	2/58
Dog	*Canis familiaris* L.	1/22
Human	*Homo sapiens* L.	1/85

Negative examinations (with numbers of each species examined in parentheses): heather vole, *Phenacomys intermedius* Merriam (4); wood rat, *Neotoma cinerea* (Ord) (2); yellow pine chipmunk, *Eutamias amoenus* (Allen) (8); snowshoe hare, *Lepus americanus* Erxleben (2); wolf, *Canis lupus* L. (9); coyote, *Canis latrans* Say (3); black bear, *Ursus americanus* Pallas (10); grizzly bear, *Ursus arctos* L. (9); white-tailed deer, *Odocoileus virginianus* (Zimmermann) (3); moose, *Alces alces* (L.) (6); wapiti, *Cervus elaphus nelsoni* V. Bailey (1); cat, *Felis domesticus* L. (1); Canada goose, *Branta canadensis* L. (1).

been isolated from any water supplies in this area. Beaver feces containing *Giardia* cysts, however, were found during the Banff outbreak in 40 Mile Creek which was the sole source of drinking water for the town.

MATERIALS AND METHODS

Fecal samples, and occasionally whole animal carcasses, were collected during 1983 in Banff National Park by the Park Warden Service. Additional specimens were collected in the Kananaskis Valley in 1982 and 1983. Wild animal (Table 1) and some dog feces were sampled during field expeditions. Dog feces were obtained primarily from the Banff Animal Shelter and human fecal samples were taken from pit privies at campgrounds in the Kananaskis Valley. No more than three samples were taken from each privy on each weekly sampling trip and care was taken to ensure that the samples were not duplicates. Samples were only taken if they were still moist, had not been exposed to direct sunlight, and were obviously fresh. All samples were preserved in SAF preservative (15 g sodium acetate, 20 ml glacial acetic acid, 40 ml formalin, dissolved in 1 liter of water). The sucrose/water centrifugation method of Roberts-Thomson et al. (1976) was used to detect cysts in fecal samples. Intestinal scrapings were examined in all of the red-backed voles and in 25 of the deer mice.

Feces containing *Giardia* cysts were obtained from the rectum of a beaver trapped in the Kananaskis Valley. The fecal material (in saline) was airshipped to the Institute of Parasitology of McGill University where the cysts were concentrated using the method of Roberts-Thomson et al. (1976). These cysts were introduced to Mongolian gerbils according to the procedures of Faubert et al. (1984). Trophozoites scraped from the small intestines of the gerbils 15 days after infection were purified using the methods of Andrews et al. (1980) and Feely and Erlandsen (1981). The trophozoites were then cultured using Diamond's TYI-S-33 medium (Diamond et al., 1978; Belosevic et al., 1983a).

RESULTS

The results from the animal and human survey are summarized in Table 1. Of the 304 samples analyzed, 32 (10.5%) were found to contain cysts of *Giardia* spp. Positive samples were found from beavers, humans, red-backed voles, meadow voles, dogs, deer mice, and long-tailed voles. The majority of the positive feces were from voles, the red-backed vole in particular.

Cysts obtained from the small intestine of a beaver were successfully introduced to gerbils. In experimental infections, gerbil feces were found to contain cysts of *Giardia* spp. after 5 days and they were detected intermittently in their feces for the next 25 days. Trophozoites of *Giardia* spp. were successfully removed from the small intestines of gerbils and cultured in Diamond's TYI-S-33 medium. This strain has been subcultured and is being maintained at the McGill Institute of Parasi-

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tology and the National Institutes of Health at Bethesda, Md. (strain designation IP:0483:1).

DISCUSSION

The results from the animal survey are comparable to the overall prevalence of infection found by Davies and Hibler (1979) who found that 65 of 744 (8.7%) animal and human fecal specimens obtained in Colorado contained cysts of *Giardia* spp. Their study obtained samples from 33 species of animals including humans, 13 more than were sampled during this study. They found the highest prevalence of *Giardia* infections in domestic cats (25%; *Felis domesticus* L.), beaver (18%), dogs (13%), and cattle (10%; *Bos taurus* L.). In this study the prevalence of *Giardia* in beavers and dogs was 3.5% and 5% respectively. Lewis (pers. comm.) found that 10% of 1,000 dog feces sampled from animal shelters in Alberta contained cysts of *Giardia* spp., suggesting that either the results obtained in the present survey are low or that confinement and frequency of direct contact indoors may increase the rate of infection. Davies and Hibler (1979) did not report any results from voles in Colorado, but we found that the overall prevalence among the four species in the study area was 73% (22/30). Grant and Woo (1978) found 98.8% of 326 meadow voles were infected in southern Ontario, suggesting that these animals commonly harbor *Giardia*. They also found that 48 of 49 (98%) deer mice were infected compared with five out of 43 (11.6%) in this study.

In a similar study in Washington state Frost et al. (1982) obtained fecal specimens from 656 beavers, 172 muskrats (*Ondatra zibethicus* L.) and 83 other animals. They found that the prevalence of infection among beavers was 10.5% whereas 51.2% of muskrat samples contained *Giardia*. The potential for human infectivity of *Giardia* cysts taken from muskrats has not been evaluated but the high prevalence of infection reported by Frost et al. (1982) indicated that an investigation of human pathogenicity is warranted. If *Giardia* cysts taken from muskrats are found to be infective to humans, these animals may be even more important than beaver in zoonotic transmission of giardiasis. None of the other animal feces sampled by Frost et al. (1982) including seven nutria (*Myocastor coypus* Geoffroy St.-Hilaire), 12 mink (*Mustela vison* Schreber), 28 raccoons, 19 river otters (*Lutra canadensis* Goldman), eight bobcats (*Felix rufus* (Schreber)), two coyotes (*Canis latrans* Say), one lynx (*Lynx canadensis* Kerr) and six mountain beavers (*Aplodontia rufa* Richardson) contained cysts.

It is worthy of note that different methods of feces preservation and analysis were used for the studies discussed above. Davies and Hibler (1979) used both 2% and 10% formalin for preservation followed by zinc sulfate flotation. Grant and Woo (1978) used direct examination of intestinal scrapings, wet mounts of cheesecloth filtered feces, and zinc sulfate flotation. Lewis (pers. comm.) used SAF preservation and zinc sulfate flotation. Trials in our laboratory showed that the sucrose (S.G. 1.11) method could recover approximately 18% of 3,000 cysts contained in 5 ml of water. Similar trials using $ZnSO_4$ (S.G. 1.18) and $NaNO_3$ (S.G. 1.18) flotation recovered less than 1% of 13,000 cysts placed in a centrifuge tube and subsequently filled with the appropriate solution. Feces from infected animals often contain at least thousands of cysts/g so these differences in methodology have probably not seriously affected the comparability of the different surveys.

Despite the differing methods of cyst detection, the average prevalences reported among wild animals and dogs from animal shelters are similar. Individual host species, however, were shown to have very different prevalences of infection. This has also been reported for human populations.

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Harter et al. (1982) found 37 out of 518 children to contain cysts in their feces in Washington state whereas Schmidt and Roberts (1981) reported that infection rates throughout the world range from 2.4 to 67.5% based on surveys of 134,966 people. They stated that 7.4% of the population in the United States was infected using data from a survey of 25,299 people. Lower results were reported by the Centers for Disease Control (1978) who found specimens of *Giardia* spp. in 3.8% of 414,800 fecal samples examined in the United States. Much higher prevalence has been reported in day-care centers (Black et al., 1977; Keystone et al., 1978) indicating that frequency of contact may be important in the transmission of infection. The prevalence of human infection is also strongly influenced by the level of sanitation. Data from animal surveys are more restricted but the information presented in this paper suggests that large fluctuations in animal infection prevalences occur. The extent to which this is a function of contact with humans is unknown.

The cysts taken from the beaver were of the *Giardia duodenalis* type (Felice, 1952) and therefore similar to *Giardia* isolated from humans. This conclusion is supported by the intermittent pattern of cyst release in gerbils (Rendtorff, 1954; Belosevic et al., 1983b; Faubert et al., 1984) and the subsequent culturing of the trophozoites taken from gerbil intestines. Similar findings were obtained using cysts isolated from a beaver trapped near Banff in 1982 (Faubert et al., 1984). The possibility of waterborne human giardiasis therefore exists in the Kananaskis Valley.

The *Giardia* cysts found in microtines were presumably *Giardia muris* (Grassi, 1879) and probably not infective to humans. These assumptions could not, however, be verified.

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