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GIARDIA CONTAMINATION OF SURFACE WATERS: A SURVEY OF THREE SELECTED BACKCOUNTRY STREAMS IN ROCKY MOUNTAIN NATIONAL PARK

WATER RESOURCES REPORT NO. 86-2

WATER RESOURCES DIVISION
NATIONAL PARK SERVICE
COLORADO STATE UNIVERSITY
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GIARDIA CONTAMINATION OF SURFACE WATERS: A SURVEY OF THREE SELECTED BACKCOUNTRY STREAMS IN ROCKY MOUNTAIN NATIONAL PARK

Water Resources Report No. 86-2

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ABSTRACT

Three remote backcountry streams in Rocky Mountain National Park were surveyed for Giardia contamination during the summer of 1985. Stream water pumped through a 1.0 micron filter apparatus was analyzed for Giardia using a zinc sulfate centrifugation technique. Notes were taken as to the type of habitat and wildlife found at the sampling sites.

Giardia cysts were not found in any of the water filter samples taken from two of the streams sampled. Both of these streams are in low human-use areas with poor beaver habitat. Giardia cysts were found in two of nine water filter samples taken along the third stream. This stream flows through a low human-use area containing marginal beaver habitat. Beaver were in residence in the vicinity of the sampling sites at which Giardia cysts were detected.

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INTRODUCTION

Literature Review

Giardia, a parasitic protozoan, has become recognized relatively recently as being pathogenic to humans. The infection it causes, giardiasis, can lead to a wide spectrum of disease symptoms ranging from asymptomatic infections to a debilitating maldigestion-malabsorption syndrome (Solomons 1982). Some of the more commonly reported symptoms include diarrhea, abdominal cramps, flatulence, greasy and foul-smelling stools, abdominal bloating, fatigue, weight loss, anorexia, and nausea (Moore et al. 1969; Walzer et al. 1971; Osterholm et al. 1981).

Giardiasis is a cosmopolitan infection with prevalence rates varying from 1 to 30 percent worldwide (Kulda and Nohynkova 1968). It is the most commonly identified intestinal parasite in the United States (Medical News 1978) and in the United Kingdom (Knight and Wright 1978). From 1977 to 1979, 4 percent of all stool specimens submitted to state health department laboratories contained *Giardia* cysts (WHO 1981).

This parasite, as is true of most gastrointestinal parasites, is most commonly transmitted by direct person-to-person fecal-oral contamination. The World Health Organization (WHO 1981) considers this to be the principal mode of *Giardia* transmission among humans. *Giardia* is a particular problem in day-care centers and nursery schools where inadequate hygiene habits of children promote transmission. The first such cases were reported in England in 1942 (Ormiston et al. 1942).

Waterborne transmission of giardiasis was first reported in tourists traveling in the Soviet Union in 1970 (Walzer et al. 1971; Brodsky et al. 1974). Numerous waterborne outbreaks of giardiasis have since been reported in many communities throughout the United States

including Aspen, Colorado (Moore et al. 1969); Rome, New York (Shaw et al. 1977); Camas, Washington (Dykes et al. 1980); Berlin, New Hampshire (Lopez et al. 1980); Bradford, Pennsylvania (Lippy 1981); and Aspen Highlands, Colorado (Istre et al. 1984). There is also a report of a waterborne giardiasis outbreak following a camping trip in the remote mountains of Utah that affected 34 of 54 campers (Barbour et al. 1976). These waterborne outbreaks of giardiasis have occurred primarily in areas where surface water sources are free of gross human sewage contamination and thus where water treatment is minimal (Craun 1984).

In the absence of an obvious human source of Giardia contamination of surface water sources, beaver have been implicated as the source of contamination (Craun 1984). Cross-transmission studies have shown that human-source Giardia cysts can establish infections in domestic dogs and captive beaver, and beaver-source Giardia cysts can establish infections in domestic dogs and human volunteers (Davies and Hibler 1979). Therefore, giardiasis must be considered a zoonotic disease transmittable from humans to some animals and from some animals to humans.

In a three-year survey of commercially-trapped mammals in the state of Washington, the incidence of Giardia ranged from 6-19 percent in beaver and 35-43 percent in muskrats (Frost et al. 1983). In Colorado, Davies and Hibler (1979) tested 244 beaver for Giardia, and 44 (18 percent) were found to be infected.

Giardia in Rocky Mountain National Park

In a study conducted during 1983 and 1984 in the Hidden Valley area (2,900 m elevation) in Rocky Mountain National Park, 525 of 1257 beaver fecal samples (42 percent) were positive for Giardia cysts (Monzingo 1985). All age groups of beaver were shedding Giardia cysts in their

feces throughout the year. The author concluded that beaver and possibly muskrat, the only other wildlife species of those sampled in Hidden Valley that was found to be shedding Giardia cysts, could serve as amplification hosts of waterborne Giardia.

This same study examined surface waters for Giardia contamination in and surrounding the Hidden Valley beaver colony. No Giardia cysts were detected in eleven water filter samples, totaling 13,593 ℓ, taken above the pond system of the beaver colony. Water filter samples taken within the pond system were found to contain Giardia cysts in 9 of 16 samples totaling 21,746 ℓ of water. The concentration of cysts in positive water samples taken from the pond system ranged from 15 to 611 cysts per 1000 ℓ. Giardia cysts were also detected in 15 of 46 water filter samples, totaling 63,252 ℓ, taken downstream from the pond system. The positive samples were those taken in the late spring (June) and early fall (September and October), when beaver migrations and dam repair activity were occurring. Cyst concentrations in these samples ranged from 5 to 112 cysts per 1000 ℓ of water.

In 1984, the Loch Vale and Glacier Gorge basins in Rocky Mountain National Park were examined for water quality (Kunkle et al. 1985). These are high-elevation (9,900 ft to 11,600 ft or 3,000 m to 3,500 m) watersheds which are heavy human-use areas: an estimated 9,800 hikers used the area during the 1984 summer season. Giardia cysts were found in 7 of 35 water filter samples with cyst concentrations ranging from 3 to 10 cysts per 1000 ℓ. The sampling sites were on streams that passed through two campgrounds and two bivouac sites but no active or inactive beaver pond systems. The source of Giardia contamination—human, wildlife, or mixed—could not be reliably identified.

Purpose of the Study

As a result of the above studies, one in an active beaver pond area (Monzingo 1985) and the other in a high human-use area (Kunkle et al. 1985), the need was identified to examine the presence of *Giardia* in the remote backcountry streams of Rocky Mountain National Park in areas of poor or marginal beaver habitat and low human use. The two previous studies had shown that the potential for contamination of surface waters with *Giardia* cysts is high in active beaver ponds and moderate in heavy human-use areas. The present study was conducted in July and August of 1985 to determine the degree, if any, of *Giardia* cyst contamination of streams in non-beaver habitat, low human-use areas of Rocky Mountain National Park.

MATERIALS AND METHODS

Sampling Sites

D. R. Stevens, Research Biologist for Rocky Mountain National Park, identified three representative drainages to be sampled within the park. These drainages, the North Fork of the Big Thompson River, Hague Creek, and East Inlet Creek to Grand Lake, are characterized by poor or marginal beaver habitat and low human-use. The quality of beaver habitat was estimated based upon the presence or absence of the preferred beaver foodstuffs (willow [*Salix* spp.] and aspen [*Populus tremuloides*]) and the stream gradient, which is a critical factor in the building and maintenance of beaver dams. The degree of human use was estimated from the number of camping permits issued for each area. Locations within the park of these three drainages and the previously studied Loch Vale and Glacier Gorge basins and Hidden Valley beaver

colony are shown in Figure 1. Descriptive data for each sampling site along the present three study drainages are contained in Table 1.

Water Filter Collection

Water filtering equipment was backpacked into the remote drainages by study personnel and a Park Service llama. The equipment consisted of a 12-volt gel-filled or dry cell battery, a 12-volt marine bilge pump, 3/4 in. (19 mm) hose, a filter housing containing a wound polypropylene 1.0 micron filter, and a household water meter, as described by Kunkle et al. (1985) and Monzingo (1985) (Fig. 2).

The water filter apparatus was set up at sampling sites during the day and allowed to operate throughout the night (Fig. 3). The next day the apparatus was disassembled and 3/4 in. (19 mm) pipe-fitting plugs placed in the inlet and outlet of the filter housing containing the

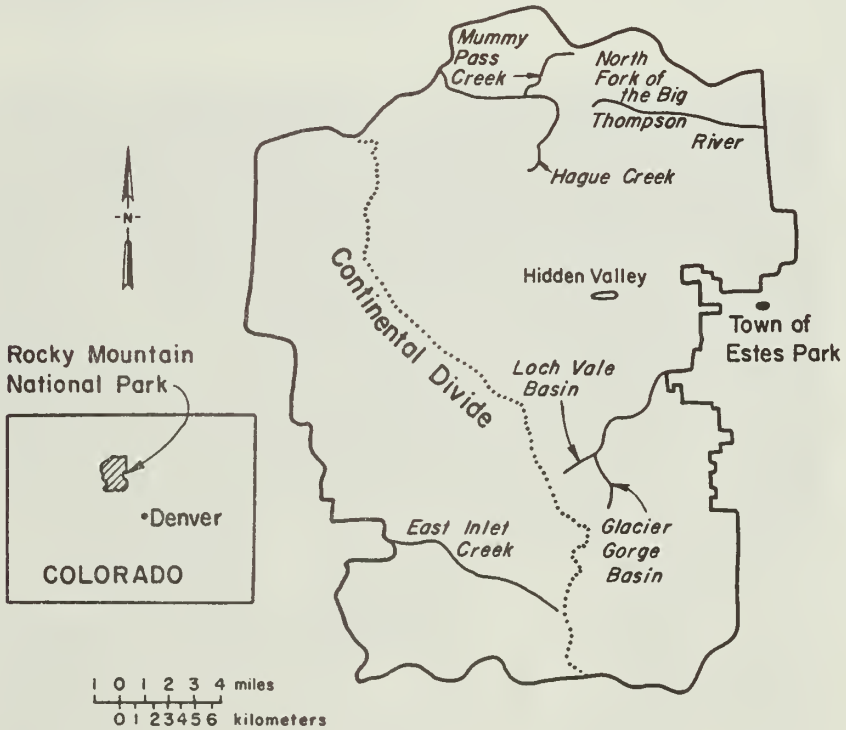

Figure 1. Rocky Mountain National Park, showing former and present study areas and relative location in Colorado (adapted from Kunkle et al., 1985).

Table 1. Sampling sites and descriptions.

Drainage Basin	Filter Number	Location	Terrain	Beaver Habitat*	Elevation
North Fork of the	1	Ranger Station	Forested	Poor	9,200 ft (2829 m)
Big Thompson River	2	Lost Meadow	Meadow (grass)	Very Poor	10,400 ft (3170 m)
July 1 and 2, 1985	3	Lake Husted (outlet)	Tundra	Very Poor	11,040 ft (3365 m)
	4	Lake Louise (outlet)	Tundra	Very Poor	11,120 ft (3389 m)
Hague Creek	1a,b	Top of lower meadow	Meadow (willow)	Marginal	10,040 ft (3060 m)
Trip #1	2	Middle of upper meadow	Meadow (willow)	Marginal	10,160 ft (3097 m)
July 15-17, 1985	3	Unnamed side creek	Tundra	Very Poor	11,000 ft (3353 m)
	4	Above alpine ponds	Tundra	Very Poor	11,400 ft (3475 m)
East Inlet Creek	1a,b	Lone Pine Lake (inlet)	Forested	Very Poor	9,830 ft (2996 m)
July 22-24, 1985	2	Lake Verna (inlet)	Forested	Very Poor	10,240 ft (3121 m)
	3	Spirit Lake (inlet)	Forested	Very Poor	11,320 ft (3450 m)
	4	Fourth Lake (inlet)	Tundra	Very Poor	11,400 ft (3475 m)
Hague Creek	1	Bottom of upper meadow	Meadow (willow)	Marginal	10,100 ft (3078 m)
Trip #2	2	Top of upper meadow	Meadow (willow)	Marginal	10,200 ft (3109 m)
August 19-21, 1985	3a,b	Mummy Pass Creek	Meadow (grass)	Marginal	10,170 ft (3100 m)

*Beaver habitat was evaluated based upon stream gradient and the local availability of willow and aspen.

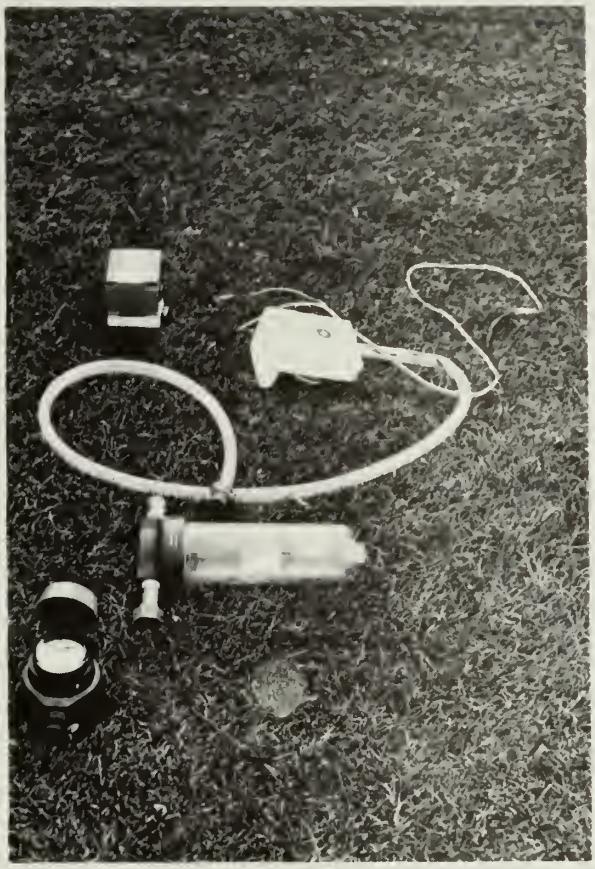

Figure 2. Giardia sampling system, showing (clockwise from upper left) a 12-volt gel-cell battery, bilge pump inserted in styrofoam collar, plastic tubing, filter housing, and water meter.

Figure 3. Giardia sampler operating in a stream. In this case a 12-volt dry cell battery has been substituted for the gel-cell battery.

filter. These housings were left in the streams to keep them cool until they could be backpacked to the trail head and transported on wet ice to the Department of Pathology Parasitology Laboratory at Colorado State University. Water filter analysis was completed within 36 hours of leaving the trailhead.

Water Filter Analysis

At the Parasitology Laboratory, filters were removed from the housings and the polypropylene filter windings cut from the core of the cartridge. Windings were hand-rinsed in a half gallon of cold (3°C) distilled water to remove all trapped debris. The water in the filter housing was added to the rinse water and the suspension placed in a refrigerator at 3°C to settle overnight.

The sediment was prepared for examination the next day using a zinc sulfate centrifugation technique (APHA 1985) modified by Dr. Charles Hibler of the Colorado State University Department of Pathology*. Twenty mℓ of the sediment was layered over 20 mℓ of 1.18 specific gravity (sp gr) zinc sulfate solution in a 50 mℓ conical centrifuge tube. This was centrifuged at 1500 rpm (970 g) for 5 minutes. The top layer was drawn off with a needle and syringe and transferred to another 50 mℓ centrifuge tube. Cold distilled water was added to fill the tube and the tube was spun at 1500 rpm for 5 minutes. The supernatant was siphoned to the pelleted centrifugate and the pellet resuspended in 10 mℓ of cold distilled water. This was transferred to a 15 mℓ conical centrifuge tube and spun for 5 minutes at 1500 rpm. The supernatant was again siphoned to the pellet and 2-3 drops of Lugol's

*Laboratory testing of this filtering and analysis procedure yielded 85 percent recovery efficiencies for Giardia cysts (C. Hibler, personal communication).

iodine and 5 mℓ 1.20 sp gr zinc sulfate solution added to facilitate resuspension. The pellet was resuspended and sufficient 1.20 sp gr zinc sulfate solution was added to form a convex meniscus. A glass coverslip was placed on top of the tube and this was spun at 1500 rpm for 5 minutes. The coverslip was removed, placed on a glass slide, and the entire coverslip examined at 100x magnification.

RESULTS

The results of the water filter analyses are shown in Table 2. No Giardia cysts were detected in four water filter samples from the North Fork of the Big Thompson River or in five samples from the East Inlet Creek. Four water filter samples—1a, 1b, 3, and 4—taken along Hague Creek on the first sampling trip also did not contain Giardia cysts. Filter sample number 2, taken from the middle of the upper meadow in Hague Creek, contained 24 Giardia cysts in 2309 ℓ (508 gal) of sampled water for a cyst concentration of 10.4 cysts per 1000 ℓ (4.72 cysts per 100 gal).

These results necessitated a second collection trip to Hague Creek to concentrate the sampling in the upper meadow in an attempt to determine the source of the Giardia cysts found after the first sampling trip. On this second trip, filter number 2 from the upper end of this meadow and filters 3a and 3b from Mummy Pass Creek where it enters the meadow did not contain Giardia cysts. Filter number 1, from the bottom end of the meadow, contained 108 cysts in 6669 ℓ (1467 gal) of sampled water for a cyst concentration of 16.2 cysts per 1000 ℓ (7.36 cysts per 100 gal). This filter was below two new beaver dams built in the weeks between the first and the second Hague Creek sampling trips.

Table 2. Results of water filter analysis.

Basin	Filter Number	Volume Filtered (ℓ)	(gal)	Total Cysts	Cysts/1000 ℓ	(Cysts/100 gal)
North Fork of the	1	441	(97)	0	0	(0)
Big Thompson River	2	3,850	(847)	0	0	(0)
July 1 and 2, 1985	3	4,014	(883)	0	0	(0)
	4	2,196	(483)	0	0	(0)
	Total	10,501	(2,310)	0	0	(0)
Hague Creek	1a	3,014	(663)	0	0	(0)
Trip #1	1b	3,155	(694)	0	0	(0)
July 15-17, 1985	2	2,309	(508)	24	10.4	(4.72)
	3	2,073	(456)	0	0	(0)
	4	2,000	(440)	0	0	(0)
	Total	12,551	(2,761)	24	1.9	(0.87)
East Inlet Creek	1a	8,374	(1,842)	0	0	(0)
July 22-24, 1985	1b	6,283	(1,352)	0	0	(0)
	2	5,205	(1,145)	0	0	(0)
	3	1,141	(251)	0	0	(0)
	4	4,914	(1,081)	0	0	(0)
	Total	25,917	(5,701)	0	0	(0)
Hague Creek	1	6,669	(1,467)	108	16.2	(7.36)
Trip #2	2	3,028	(666)	0	0	(0)
August 19-21, 1985	3a	3,460	(761)	0	0	(0)
	3b	3,569	(785)	0	0	(0)
	Total	16,726	(3,679)	108	6.5	(2.94)

DISCUSSION

This study was designed to examine the extent, if any, of Giardia contamination of streams in areas of low human use and poor or marginal beaver habitat in the remote backcountry of Rocky Mountain National Park. The area sampled along the North Fork of the Big Thompson River and East Inlet Creek to Grand Lake are low human-use areas with poor to very poor beaver habitat (Figs. 4 and 5). The elevation gradients along these streams are too steep to allow beaver to build dams. In addition, riparian vegetation along these two streams and around their lakes includes very little willow and almost no aspen, the two main components of a typical beaver diet. Giardia cyst contamination of these streams from 9,000 ft to above 11,000 ft (2,743 m - 3,353 m) elevation was not found.

The Hague Creek basin contained marginal beaver habitat, so designated because willow is in good supply and the meadows along this stream are flat enough to allow beaver to construct dams (Fig. 6). Old abandoned beaver dams and lodges were observed in the lower and upper meadows during the first Hague Creek trip on July 15, 16, and 17. In the upper meadow a small amount of fresh beaver sign was found consisting mainly of willow branches chewed by beaver. Both meadows contain dense stands of willow 2 to 4 ft tall. However, because no aspen occurs along these meadows, the Hague Creek meadows probably could support a small beaver colony for only a year or two.

Two freshly built beaver dams not present during the first collection trip were found in August during the second collection trip at the lower end of the upper meadow of Hague Creek. Water filter number 2 on the first collection trip and filter number 1 on the

Figure 4. Lost Lake (el. 10,700 ft) on the North Fork of the Big Thompson River, Rocky Mountain National Park.

Figure 5. Lone Pine Lake (el. 9830 ft) on the East Inlet Creek, Rocky Mountain National Park.

Figure 6. Upper meadow along Hague Creek, showing the presence of willow that characterizes the marginal beaver habitat at this elevation (10,160 ft).

second collection trip to Hague Creek were both from within the area of beaver activity. These were the only water filter samples that contained Giardia cysts. Beaver in this area are known to be infected with Giardia (Hibler, personal communication; Monzingo, unpublished data), and there was no evidence of human contamination of this stream. Therefore, the source of the cysts appeared to be the beaver that built the dams.

CONCLUSIONS

When these results are considered together with the data collected by Kunkle et al. (1985) and Monzingo (1985), a pattern of Giardia cyst contamination of the surface waters in Rocky Mountain National Park begins to emerge. Monzingo (1985) detected a high degree of Giardia cyst contamination of surface waters in the well-established beaver ponds of Hidden Valley (15 to 611 cysts per 1000 ℓ) and, on a seasonal basis, in the stream below this pond system (5 to 112 cysts per 1000 ℓ). Kunkle et al. (1985) detected a moderate degree of Giardia cyst contamination of surface waters in the high human-use areas of Loch Vale and Glacier Gorge (3 to 10 cysts per 1000 ℓ). A moderate degree of Giardia cyst contamination also was detected in the low human-use, marginal beaver habitat area of Hague Creek (10.4 to 16.2 cysts per 1000 ℓ). Giardia cyst contamination of surface waters was not detected in the low human-use, poor beaver habitat areas of the North Fork of the Big Thompson River and the East Inlet Creek.

In view of data from the present and previous studies conducted in Rocky Mountain National Park, the risk of ingesting a Giardia cyst from consuming unfiltered, untreated surface waters in the park should be considered high in areas where beaver are active, moderate in marginal beaver habitat and high human-use areas, and low in areas of poor beaver habitat and low human use. Determining the extent to which this principle might apply in other national park units would be speculative at best. Beaver are excellent reservoir hosts and should always be considered potential Giardia carriers. Wildlife other than beaver may also be carrying Giardia in some areas, and septic systems or sewage effluent could introduce Giardia into streams flowing through parks in

more populated regions. Even in Rocky Mountain National Park, beaver will sometimes migrate upstream into areas of poor beaver habitat, especially in the summer and early fall, and the occasional hiker in a low human-use area could temporarily contaminate a stream. Further research would be necessary to distinguish the different sources of Giardia and their relative effects on surface water quality. For the present, though overall risk in some areas is very low, no surface waters should be considered entirely free of risk of contamination with Giardia.

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