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Introduction

The *Giardia lamblia* (Lambl) protozoan is not a recently discovered parasite. It was. in fact, one of the first organisms viewed and described by Antony van Leeuwenhoek (1681) as he designed the first usable microscope. Leeuwenhoek found this organism in a sample of his own diarrhetic stool and thus he constitutes the first confirmed case of human giardiasis. His finding represents proof of glardiasis' close association with man for many years. Leeuwenhoek's discovery of the giardial trophozoite was not elaborated on for some 178 years, however, as it was not until 1859 that Wilhelm D. Lambl systematically described the organism as being a distinct genus of protozoan parasite (Kudo 1966). Unfortunately Lambl made little mention of guardias' medical significance and the giardial protozoan was not accurately recognized as a major health concern until late in the twentieth century.

In 1981 the World Health Organization finally recognized *Giaradia lamblia* (Lambl) as a major public health concern world wide and called for intensive epidemiological investigations of the protozoan and its zoonotic nature (WHO 1981). Giardia was officially recognized as a zoonotic disease.

Giardia lamblia lamblia as we know it today is radically different than the organism presented to many of us in our undergraduate parasitology classes. Once thought to be a benign organism; perhaps even symbiotic, it is now proven to be a potentially debilitating and possibly lethal parasite (McGrath 1940). Until recently it was thought to be very host specific but is now known to be grossly catholic in its parasitic invasions. Previously considered to be a genus consisting of many, perhaps hundreds, of species it is now suspected of consisting of as little as three distinct species. Human giardiasis was once thought to be transmitted only from person to person through poor hygiene or through water tainted by human waste, but now we know it to be a zoonotic parasite, easily transmitted by any number of different animals (Tables 1 and 2) or their contamination of our water. Due to these new findings the *Giardia* sp. of our schooling does not remotely resemble the one presented in today's literature. Unfortunately this is also true for many of the physicians in practice, today. Thus, it is easy to understand why many doctors are so slow to recognize and accept giardial infection.

Since some physicians are unaware of this new knowledge and are ignorant of giardias' current abundance in the United States, it is recommended that anyone potentially at risk to a giardial infection secure a copy of Patient Care's article "When Protozoan Invade the GI Tract" (pp. 224-253). The article nicely describes a giardial infection, but of particular interest to the potential giardiasis victim, is the suggestions that doctors need not waste time and money running lab tests in an attempt to conclusively prove a case of giardiesis. Instead, they can test by therapeutic trial. A therapeutic trail is the treating of the disorder (symptoms) with the appropriate drug to see if such a treatment cures the symptoms. The

Table 1. Evidence of Cross Species Infections: (35).

Giardia cysts of beaver origin:

Positive Results	Negative Results
Dogs (4 out of 4) *Canis familiaris*	Hamsters *Mesocricetus auratus*
Humans (2 out of 3) *Homo sapiens*	Guinea-pigs *Cavia porcellus*
	Mice *Mus musculus*
	Rats *Rattus norvegicus*

Giardia cysts of mule deer

Positive results	Negative Results
Human *Homo sapiens*	Dog *Canis familiaris*

(Davies et al, 1978)

Table 2. Evidence of Cross Species Infections.

Giradia cysts of human origin:

Positive Results	Negative Results
Rat *Rattus norvegicus*	Hamsters *Mesocricetus auratus*
Gerbil *Gebillus gerbillus*	Domestic rabbits *Oryctolagus cunicul*
Guinea-pig *Cavia porcellus*	Lab mice *Mus musculus*
Dog *Canis familiaris*	Deer mice *Peromyscus meniculus*
Raccoon *Procyon lotor*	Black bear *Ursus americana*
Cross between bighorn and mouttonsheep	Wapiti *Ceruus canadensis*
Ovids canadensis 0. musimon	Mule deer *Odocuileus hemionus*
Pronghorn Antelope *Antilocapra americana*	Domestic sheep *Ouis aries*
	Cattle *Bos spp*.
	White-tailed deer *Odocoileus virgini*

(Davies et al, 1978)

therapeutic trial results either in a cured infection (ie. and of symptoms), or in cases, where giardia was not the problem, indicates such, by having no effect in eliminating the symptoms (Borgatti 1983).

It is important to realize that the proper treatment for a giardial infection requires at least 3 fecal samples to be taken over a period of 1 week during which time the patient should be symptomatic (Wolfs 1979). However, some patients cannot be shown to have a giardiai infection through a standard lab test series and, therefore, a negative test result actually tells you very little (Meyer 1984, Ament 1972). A positive finding is, however, conclusive.

Because many Sim" infections are difficult to demonstrate in the lab, the therapeutic approach is often the more practical path to take. The cost of the appropriate medication used in a trial should be less than $30.00. This is low when compared to lab costs, which are often in excess of $100.00. Additionally, the therapeutic trial will show results in less than 1 week, often before the lab test results are finalized. This savings in time represents a reduction in the patient's exposure to the inconvenience and discomfort of giardial symptoms. Therefore, if one has reason to believe that they may have had contact with a source of gierdia, and are experiencing some or all of the symptoms common to giardiasis, a therapeutic trail is certainly a reasonable approach in determining an infection.

Giardiasis is extremely variable in its effects; as much as 8096 of those infected are asymptomatic or demonstrate such a low level of severity in their symptoms that they fail to recognize their illness. These people are generally not inconvenienced by the infection but are nonetheless carriers of the disease and are capable of passing it on. Those who do exhibit symptoms will vary considerably in severity. The primary symptoms of an acute giardial attack are listed in Table 3.

Giardiasis has 2 phases, the acute phase and the chronic phase. The acute phase is symptomatically severe and generally lasts no more than 3 weeks. The chronic phase is generally less debilitating but may persist indefinitely. Some people exhibit little or no symptomatic response to the initial infection. in effect bypassing the acute phase. They then become chronic carriers for an indefinite period. During the chronic phase one may experience periodic symptomatic bouts of diarrhea, heartburn, distention, and flatulence, often interspersed with constipation. A general complaint of chronic phase victims is constant stomach rumblings, ulcer-like burning in the lower stomach area, and late night attacks of caustic heartburn. (Peace Corps personnel christened the caustic heartburn occurrence as "the purple burp"!).

In the acute phase, giardiasis can be life-threatening to the very young, the elderly, and to a select few who show a sensitivity to the organism. Evidence indicates a connection exists between sensitivity to giardial attack and a predisposition to allergies or a lowered immune response capacity (WHO 1981).

In many cases, chronic giardiasis can be toleraed and ignored as nothing more than a periodic nuisanec. Often, though, giardial symptoms lead to misdiagnosis of chronic gastrointestinal disorders because many of the chronic giardial symptoms resemble other maladies (eg. stomach ulcers). Consequently, chronic carriers may subject themselves to medications and testing they do not require.

Three of the primary drugs available for treatment of giardial infection are listed in Table 4. Although Atabrine is listed as the drug of choice and Plagyl is considered to be an investigational drug'by the U.S. Food and Drug Administration for this malady (Borgatti 1983, Levi et aL 1977), I have found most Texas physicians favor Falgyl. and are reluctant

Table 3. Primary reported symptoms of Giardiasis: -

Symptoms:	Percentages:*	Percentages:**
Nausea	53%	60%
Abdominal cramps	75%	61%
Flatulence	52%	35%
Lethargy	81%	N/R
Watery diarrhea	78%	96%
Weight loss	63%	62%
Weakness	N/R	72%
Greasy stools	N/R	57%
Abdominal distention.	N/R	42%
Vomiting	N/R	29%
Belching	N/R '	26%
Fever	N/R	15%
Median duration of illness	3.8 weeks	WR

* Wright et. al., 1977 **
Dingly, 1983

Table4. **Recommended Medication and Regime for Giardial Infection.**

	Drug	Adult Dose	Pediatric Dose
Drug of choice:	Quinacrine HCl (Atabrine)	100 mg tid after meals 300 mg day) after meals for 5 days	2 mg/kg tid (Maximum
Alternatives:	Metronidazole (Flagyl)*	250 mg tid for 5-7 days	5 mg/kg tid for 5 days
	or Furazolidone (Furoxone)	100 mg qid for 7 days days	1.25 mg/kg qid for 7

* Considered an investigational drug for this condition by the U.S. Food & Drug administration

Borgatti, 1983

to prescribe Atabrine. This may be due to the familiarity doctors have with Flagyl which is a frequently prescribed medicine in the treatment of some female disorders.

Giardiasis is the most commonly identified waterborne epidemic disease in the United States (Horwitz et al. 1976). In many of the major outbreaks, the source of infection has proven to be water related. In numerous studies where water has been the common source of infection, the origin of the parasite has not been conclusively determined. However, in a growing number of cases, riparian mammals taken from suspect water sources have proven *to* have an active infection of giardiasis (Dykes et al. 1980. Davis 1974). It is speculative as *to* whether these infected animals constitute the original point source or, like man, are merely victims of the actual point sources Certainly, a susceptible animal living within an adulterated water system would likely be infected. The problem, and a confounding factor. is that a newly infected animal quickly becomes a shedding point source and, as such, is difficult *to* differentiate from the original point source.

Of particular interest is the evidence of human involvement in the zoonotic transmission of giardiasis (Davis 1978, Meyers 1982). The transmission of the disease between lower animals and man relative to water sources represents a classic epizootic event Waterborne outbreaks of giardiasis in the United States have provided strong epidemiological evidence that human giardiasis can and does derive from zoonotic origin (Dykes et al. 19801 Shaw et al. 1977). That giardiasis is a true zoonosis is no longer in question (Meyer 1982).

Epidemiological studies in the western states of Colorado (Davies 1978) and Washington (Frost et al. 1980) involving large numbers of riparian animals have shown that these animals do indeed harbor the agent endemically. In the Colorado study, conducted from 1975-77, 44 of 244 (18%) beaver *(Castor canadensis)* examined by the zinc sulfate centrifugation technique were positive for *Giardla.* In the Washington study, conducted from 1976-79, 34 of the 145 (19%) beaver and 49 of 115 (42.6%) muskrats *(Ondatra zibethica)* proms by the formalin-ether technique were also shown to be positive. These 2 studies represent the first large scale sampling of feral riparian animal populations relative to the giardial zoonosis. Both states have a continuing incidence of reported waterborne giardiasis (Davis et al. 1978, Frost et al. 1980). and an enedmic population of beaver in their surface watersystems.

Texas also has a continual involvement with human giardiasis (Elliot et al. 1981). For the last 5 years, *Giardia* has been the number 1 intestinal protozoan parasite diagnosed from human stool samples at the Texas Department of Health Diagnostic Laboratories. The Texas Department of Health has reported a marked increase in the percentage of specimens positive for *Giardia lamblia* since 1967. During the fiscal year 1967-68, 4.9% of all stool specimens examined were positive for this parasite. By the fiscal year 1981-82, 11.9% of all stool samples examined were found positive (Dingly 1983). More importantly, it is estimated that the diagnosed population may represent only a small fraction of the actual incidence of giardiasis. The prevalence rate for *Giardia* in asymptomatic people is estimated to range from 1.1% to 12.5% of the population. It was found in 7.4% of 35,299 persons in 24 surveys in the United States, and in 6.9% of 65,295 persons in the rest of the world (Levine 1973).

Texas also has a large endemic population of beaver active over much of the east and northeastern portion of the state (Davis 1974, Texas Rodent & Predatory Animal Control Records 1982). These beaver are directly associated with much of the surface water sources in the state. Much of this water is used for drinking water (human and livestock), recreational activities, irrigation. and other purposes Certainly, this is a situation that allows for a potential human-beaver interface.

Indeed, the beaver does interact with mankind Every year an increasingly large number of complaints are lodged with the Texas Rodent and Predatory Animal Control Service against the beaver for damage or nuisance (eg. defoliation, flooding, erosion, etc.). These complaints result in the removal of approximately 1700 beaver each year through selective animal damage control (ADC) activities (Texas Rodent & Predatory Animal Control Records 1982).

The beaver being removed during animal damage control activities constitute a fairly representative sample of the Texas beaver population associated with man. Regardless of whether these beaver represent a sentry host animal, reflecting the health of our water system or a point source for further contamination of our water, the extent of their involvement is worthy of epidemiological examination With the cooperation and assistance of the Teals Rodent and Predatory Animal Control Service, the U.S. Fish and Wildlife Animal Damage Control Service, and the Department of Veterinary Public Health at Texas A&M University, a portion of the beaver being removed for depredation were sampled for the presence of Giardia parasites It is worth noting that this study utilized ply beaver killed during animal damage control activities and did not require the sampling of nay animal not already killed. Such sampling represents the beneficial use of an informational resource far too often underutilized (Botzler 1985).

Results of Texas Beaver Study

Samples were collected from 20 counties (Fig. 1). The majority (80%, N=16) of the counties were located is the northeastern quarter-section of Texas, with 10% (N=2) coming from the central region. and 10% (N=2) from the Texas Panhandle. A total of 68 beaver samples were collected. The distribution of the data by county is shown in Table 5. The low number of samples collected per county, and their uneven distribution, limited reliable statistical testing for giardial prevalence relative to county of sample origin. However, 15 of the 20 counties produced at least 1 *Giardia* positive beaver, proving that at least 75% of the counties tested possess a water system harboring infected, and thus infectious, beaver.

Of the 68 beaver samples collected, 45 were taken by conibear trap and 23 by shooting. A chi-square test for no difference between collection methods produced a difference ($P > 0.1471$) (Table 6). Since we had speculated that shooting might produce a higher percentage of beaver positive for Giardia than would trapping, the data were tested with this hypothesis is mind. Fisher's exact 1-tail test showed a difference at $P > 0.1161$ (SAS User's Guide: Statistic, 1982). Neither analysis method showed significant differences near P 5.05. However, considering the sample size relative to the area sampled, these trends may be worthy of note. As the beaver were not routinely sampled from each location using both sampling methods equally, a truly comparative analysis of sampling technique results is not possible.

Of the 68 beaver samples tested, 36 were found to be positive, indicating a 52.9% giardial infection rate. Compared to the 18% and 19% positive rates, respectively, of the Colorado and Washington studies. Texas appears to have a significantly higher proportion of infected beaver ($P < 0.001$) in the areas we sampled (Table 7).

If we assume a possible bias for beaver collected by shooting rather than trapping, and delete them from the study, the giardial positive rate 46.6% (N = 45) retrains significantly different ($P < .001$) from the Washington and Colorado results. Additionally, in the Washington study 42% of the muskrats (49 of 115) examined for *Giardia* proved positive. When tested against the 52.9% (N = 68) and 46.6% (N = 45) found for beaver in this study, the rate for giardial positive muskrat was not significantly different ($P > .186$ and $P > .666$ respectively).

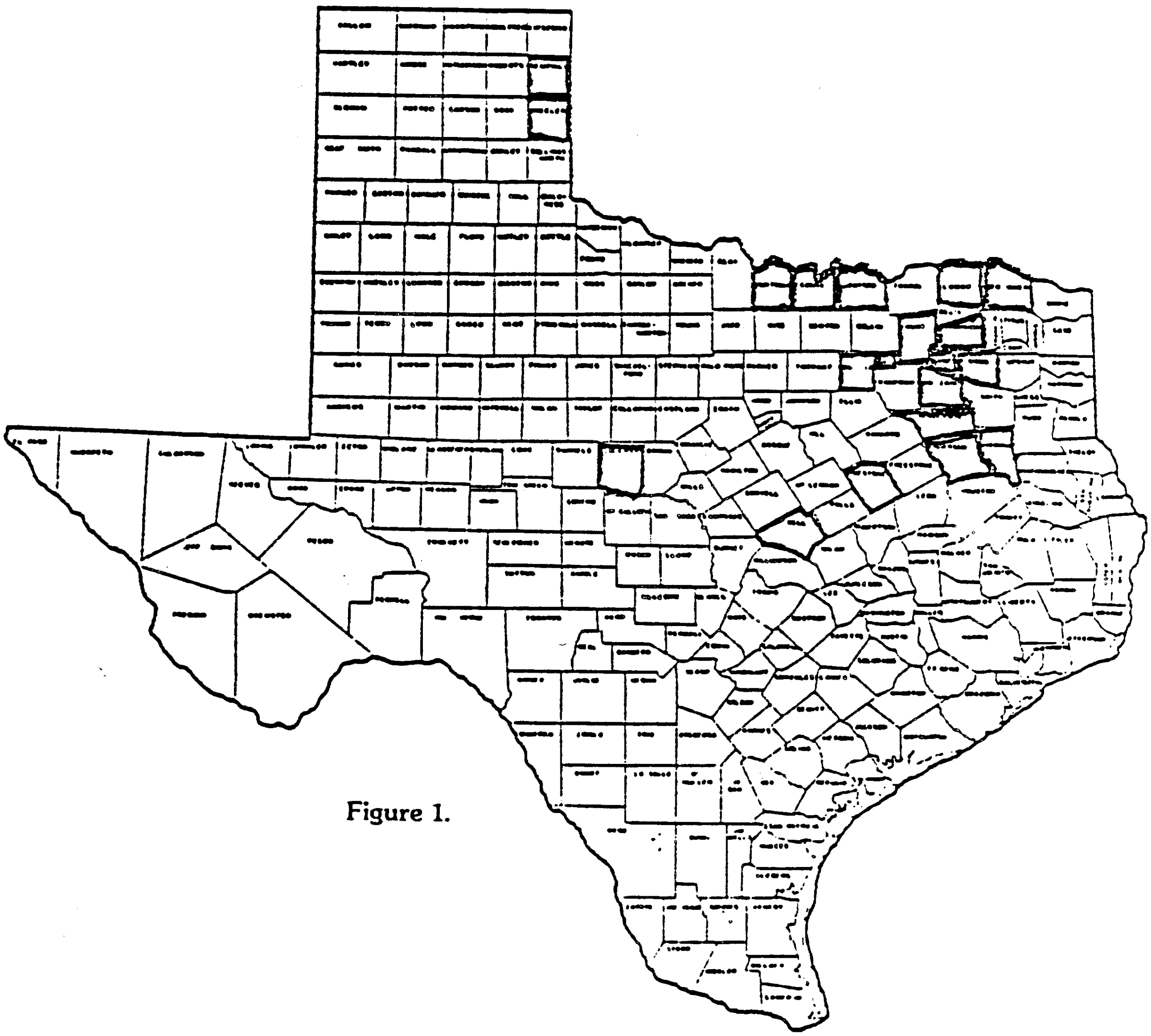

Figure 1.

Table 5. $ZnSO_4$ Results Listed per County of Origin.

County:	Number of Beaver: Pos	Neg	Total	% of Total: Pos	Neg	Total
1 Lamar	2	0	2	5.56	0.0	2.94
2 Hopkins	1	2	3	2.78	6.25	4.41
3 Rockwell	0	2	2	0.0	6.25	2.94
4 Henderson	6	2	8	16.67	6.25	11.76
5 Anderson	0	3	3	0.0	9.38	4.41
6 Cherokee	1 .	1	2	2.78	3.13	2.94
7 Rains	3	0	3	8.33	0.0	4.41
8 Wood	2	1	3	5.56	3.13	4.41
9 Hunt	2	0	2	5.56	0.0	2.94
10 Van Zandt	0	1	1	0.0	3.13	1.47
11 Grayson	2	0	2	5.56	0.0	2.94
12 Dallas	0	2	2	0.0	6.25	2.94
13 Cooke	6	8	14	16.67	25.0	20.59
14 Limestone	3	0	3	8.33	0.0	4.41
15 Bell	1	1	2	2.78	3.13	2.94
16 Coleman	1	0	1	2.78	0.0	1.47
17 Montaque	1	2	3	2.78	6.23	4.41
18 Red River	0	3	3	0.0	9.38	4.41
19 Hemphill	4	2	6	11.11	6.25	8.82
20 Wheeler	1	2	3	2.78	6.25	4.41
Total #	36	32	68	100.0	100.0	100.0
Percent	52.94	47.06	100.0			

Table 6. Testing for Difference in.Control Method Utilized in Sample Collection.

	Total Number	Number Pos.	Percent Pos.	95% Confidence Interval
Trapped beaver	45	21	46.7	+ 14.6
Shot beaver	23	15	65.2	+ 19.5
A11 beaver	68	36	52.9	+ 11.9
Collection by	x^2	DF	P =	
Trapping vs shooting*	2.102	1	0.1471	

*Fisher's Exact Test (1-Tail) Prob = 0.1161

Table 7. Testing for No Difference.

Testing for No Difference Between	Percent Positive	x^2	DF	P =
Colorado (beaver)	18			
Washington (beaver)	19			
Texas (trapped beaver)	47	19.49	2	< .001
Colorado (beaver)	18			
Washington (beaver)	19			
Texas (shot beaver)	65	28.98	2	< .001
Colorado (beaver)	18			
Washington (beaver)	19			
Texas (all beaver)	53	39.17	2	< .001
Washington (muskrat)	42			
Texas (trapped beaver)	47	0.22	1	> .666
Washington (muskrat)	42			
Texas (all beaver)	53	2.12	1	> .186

Discussion

The findings of this study indicate that Texas may have a high percentage *Giardia* positive beaver is its water systems, and that the proportion of infected beaver in the areas we sampled was significantly higher thaw that shown in the studies of Colorado and Washington beaver. As a matter of note. Davies et al. (1978) indicate a reduction in giardial positives during the colder winter months of December. January, and February. In this study, many of the beaver samples were collected during these colder months. However, it is possible that the warmer winter climate found in Texas would be more conducive to a year-round infestation than the colder climates in northern states.

In this study only the zinc sulfate test was used. Previous studies indicate that relying on just a zinc sulfate test on a 1 sample per specimen basis produces a positive in only 76% of the actual positive samples (EPA 1979, Goldman 1948). This could mean that the derived proportion of 52.9% positive represents only 76% of what was actually positive. Thus, the actual porportion of *Giardia* positive beavers in this study could have been as high as 70%.

Taking an accompanying PVA sample from the duodenal region of the sampled beaver allows for a more accurate detection of positive cases of giardial infection (Goldman et al. 1953). PVA samples were taken during this study to facilitate a more accurae detection of Giarida in the sample. However, the use of PVA for determining the prevalence rate in this, report would have biased the comparison with the Washington and Colorado studies which used a 1 sample – 1 technique procedure not involving PVA. The PVA samples were thus not utilized for determining the giardial prevalence rate and instead for verification of positives indicated by the zinc sulfate procedure.

PVA samples were examined using a permanent stain technique. One beaver detected as positive for *Giardia* using PVA could not be shown positive by several applications of the zinc sulfate method. It is thus apparent that there are more positives in the collected samples than was indicated by the zinc sulfate results.

There is some indication, although not statistically significant at the P = .05 level (P = 0.1161), that beavers collected by use of the shooting methods are more likely to be positive than those taken through trapping methods. This could be the result of the tendency for infected beavers to be more collectable after being shot (ie. it remains floating) and not a result of selective shooting. The collection of a shot beaver often mandates waiting for the carcass to float to the collector. A major symptom of giardiasis is intestinal gas formation and a disease-induced gaseous stomach could increase the floatabiliry of the beaver, thus biasing the collection process.

Conclusion

The resistant infectious stage of the giardial life cycle, the cyst, is passed in feces. A beaver can shed millions of infectious cysts in a single scat and beavers routinely defecate in the water systems they inhabit. A giardial-infected beaver can intermittently shed viable cysts through defecation for the duration of its giardial infection and evidence indicates that some giardial infections are chronic (Daaciger 1975, Davies 1978, Stevens 1982). As the life spas of the beaver is on record to be nearly 20 years (Davis 1974), a chronic infection could represent an extended period of cyst shedding. Furthermore, the cyst can remain viable within the water system for an extended period of time, particularly if the water temperature is low (Davis et al. 1978, Long 1983, Texas Preventable Disease News 1983). The giardial cyst is resistant to chlorination at the levels routinely used in drinking water and is capably of passing through the sand-type filtering systems commonly used in older drinking water systems when such filters are not coupled with chemical scrubbers (Long 1983).

Texas has a widespread population of beaver iahabitating its surface water systems and many of these systems are utilized by man, We have seen by this study that a sizable pro portion of the beaver in Texas may be harboring *Giaidia*.

We now have as idea what proportion of the beaver in our study area tray be infected with Giardla, but we do not know what the correlation is between this and contaminated watersystems. However, as it takes only one shedding beaver to contaminate a water systemthere is curtain evidence that our water systems are in danger of giardial contamination.

This study pointedly indicates a need for extensive epidemiological studies involving the association of Giardia beaver. Texas water systems, and giardiasis is man. Certainly, above groundwater sources, available for beaver influx and used for human consumption, have been shown to be worthy of suspicion.

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