Susceptibility of Domestic Cats to Infections with *Giardia lamblia* Cysts and Trophozoites from Human Sources

CARL E. KIRKPATRICK* AND GEORGE A. GREEN IV

Department of Pathobiology, School of Veterinary Medicine, University of Pennsylvania, Philadelphia, Pennsylvania

19104

Received 5 November 1984/Accepted 5 February 1985

The object of this study was to determine the importance of domestic cats in the epidemiology of human giardiasis. Of six laboratory-reared cats inoculated with cultured *Giardia lamblia* trophozoites from humans, only one showed the presence of cysts in the feces, and cysts were found on only 1 of the 80 days of observation. In a second experiment, eight cats were inoculated with *G. lamblia* cysts isolated from a human being. Over an 8-week period of observation, two of eight cats were found to have passed cysts in their feces, one on only one day and the other on 2 days. Postmortem examination of all of the cats found to be passing *G. lamblia* cysts at some time during the experiments did not reveal any small-intestinal trophozoites. These results suggest that domestic cats are relatively susceptible to *G. lamblia* from humans and, consequently, that cats probably are not significant reservoir hosts of *Giardia* spp. infective for human beings. Moreover, it appears that the *Giardia* spp. which parasitize cats are distinct from those of human beings.

Giardiasis is a common and widespread intestinal protozoal disease affecting human beings as well as a variety of other vertebrates, both wild and domestic (18, 28). In human beings, *Giardia* spp. are transmitted in the cyst stage either indirectly, through water (10, 29) or food (22), or directly, by contact with feces (7, 23). Experimental studies in animals have shown that oral administration of trophozoites may also produce infection (4, 16).

Because of their close association with humans and because the *Giardia* spp. which parasitize many mammalian hosts are morphologically indistinguishable (20, 21), companion animals have been suggested as likely reservoirs of *Giardia* spp. capable of infecting human beings (2, 3, 8, 10, 11, 16, 24, 25, 29, 33). Implications that cats are involved in the epidemiology of human giardiasis, however, are based mainly on circumstantial rather than experimental observations (5, 20, 21, 34).

This study was undertaken to experimentally determine what role, if any, is played by domestic cats in the epidemiology of human giardiasis. The results indicate that these animals are poor hosts for *G. lamblia* from humans and suggest that cats probably do not serve as reservoirs of *Giardia* spp. capable of infecting human beings.

**MATERIALS AND METHODS**

**Animals.** Laboratory-reared, Domestic Shorthair cats of both sexes were obtained from a colony at the School of Veterinary Medicine, University of Pennsylvania, Philadelphia. All of the cats were <1 year of age at the beginning of each experiment. Cats were individually housed, provided with litter pans, and offered food (Hill’s Science Diet Domestic Feline cat food; Hill’s Pet Products, Inc., Topeka, Kan.) and water ad libitum. Cats were vaccinated at least twice against feline viral rhinotracheitis, feline calicivirus, and feline panleukopenia virus infections, and they were tested and found negative for feline leukemia virus infection by an enzyme-linked immunosorbent assay of serum (DiaSystems-FeLV; Tech America Diagnostics, San Marcos, Calif.). Cages had been passed through a cage washer and disinfected with sodium hypochlorite solution (5%), and the litter pans were autoclaved. During the study, litter pans were washed and disinfected daily. The room in which the animals were kept had not previously housed animals.

Feces of each of the cats were examined by the zinc sulfate (specific gravity, 1.18) centrifugal flotation technique, a sensitive method of *Giardia* cyst detection (32), three times per week for 5 to 8 weeks before the administration of parasites. No cysts were found. In addition, cats were treated orally with a furazolidone suspension at a dosage of 4 mg/kg of body weight twice a day for 5 consecutive days. This regimen was shown previously to eliminate *Giardia* sp. infections in cats (19; C. E. Kirkpatrick and J. P. Laczak, J. Am. Vet. Med. Assoc., in press). After treatment, feces of all cats continued to be examined for 2 weeks and, again, none were found.

Inbred, male Mongolian gerbils (*Meriones unguiculatus*) were purchased from Tulebrooke Farms, Inc., West Brookfield, Mass. Gerbils were maintained in autoclaved bedding and cages fitted with filter tops. Feces of gerbils were examined several times for the presence of *Giardia* sp. cysts (as described above), and none were found. Furthermore, representative gerbils were killed and found negative for intestinal *Giardia* sp. trophozoites. Anti-*Giardia* treatment was given nevertheless, in a dosage of 20 mg of metronidazole per day administered orally by gavage, for 3 consecutive days (4). Posttreatment analyses of feces for cysts were also negative.

**Parasites and animal inoculations.** *G. lamblia* WB trophozoites were purchased from the American Type Culture Collection, Rockville, Md. (ATCC 30957). This strain was isolated from a symptomatic human patient in 1982 (31). Trophozoites were maintained in axenic culture at 35 to 37°C in TYI-S-33 medium supplemented with 50 mg of bovine bile (Sigma Chemical Co., St. Louis, Mo.), 100 U of penicillin, and 100 µg of streptomycin per ml (17). *G. lamblia* cysts were obtained from the feces of an asymptomatic, 2-year-old girl. The cysts were concentrated by zinc sulfate flotation, washed three times in sterile distilled water, resuspended in sterile saline, and kept refrigerated (4°C) until use 18 h later.

* Corresponding author.
Cats were each given $10^6$ trophozoites or $2.25 \times 10^5$ cysts in gelatin capsules by the oral route. Gerbils (six per group) were orally inoculated with $10^6$ trophozoites or $5 \times 10^5$ cysts by gavage on the same days as those on which the cats were inoculated. Feces of all cats were collected three to seven times per week beginning on postinoculation day (PID) 3. In the first experiment, in which cats were given trophozoites, two of six infected cats were killed on PID 32, and the remainder were killed on PID 80. In the second experiment, in which cats were given cysts, four of the eight cats were killed between PIDs 52 and 60. After euthanasia, the entire small-intestinal tract of each of the cats was removed, the two 1-cm sections were taken every 10 to 15 cm along the tract beginning at the pylorus. For the detection of \textit{G. lamblia} trophozoites, either sections were vigorously shaken in tubes containing cold (4°C) phosphate-buffered saline or methanol-fixed, Giemsa-stained impression smears were made of mucosal surfaces of each section. In each experiment, uninoculated gerbils or cats served as controls for environmental \textit{Giardia} contamination.

**RESULTS**

**Inoculation of cats with \textit{G. lamblia} trophozoites.** Of six \textit{Giardia}-free cats given \textit{G. lamblia} trophozoites, only one evidenced fecal cysts, and then only on PID 5. None of the remaining cats, including two uninoculated controls, were discovered passing \textit{G. lamblia} cysts in their feces over the 80-day period of observation. Postmortem examination of the entire small-intestinal tracts of each of the cats, including the one which had yielded a cyst-positive fecal sample on PID 5 (killed on PID 32), did not reveal \textit{G. lamblia} trophozoites.

The feces of two of five, three of five, and four of five gerbils which had been inoculated with the same \textit{G. lamblia} trophozoite inoculum as that given the cats were found to contain \textit{Giardia} cysts on PIDs 5, 11, and 13, respectively. On PID 13, the gerbils were killed, and the small intestines of all of them were found to contain viable \textit{G. lamblia} trophozoites. An age-matched, uninoculated group of gerbils housed adjacent to the infected ones showed no cysts in their feces, nor were they found to harbor trophozoites in their small intestines.

**Inoculation of cats with \textit{G. lamblia} cysts.** Of the eight cats inoculated with \textit{G. lamblia} cysts, only two became positive for fecal cysts, one on PIDs 24 and 33 and the other only on PID 28. On PID 52, these two cats were killed and their small-intestinal tracts were examined for \textit{G. lamblia} trophozoites as described above. No organisms were found. None of the other cats were found to shed fecal cysts over the 60-day observation period. Furthermore, two of the remaining cats were killed during the week 8 of infection, and they were not found to harbor \textit{G. lamblia} trophozoites.

To test the viability of the cyst inoculum, we gave a group of gerbils \textit{G. lamblia} cysts on the same day on which the cats were inoculated. Feces of all of the gerbils were found positive for \textit{G. lamblia} cysts on PID 8, and all of them were found to contain trophozoites on PID 13. As before none of a group of uninoculated gerbils kept next to the infected ones showed evidence of \textit{Giardia} sp. infection.

**DISCUSSION**

This study demonstrates that domestic cats are poor hosts for \textit{G. lamblia} parasites known to have infected human beings. Both stages of \textit{G. lamblia}, trophozoites and cysts, from two individual donors failed to produce sustained, patent infections in these experimental hosts. In contrast, all of 11 cats experimentally inoculated with \textit{Giardia} sp. cysts from feline sources evidenced infection in a previous study (19). The mechanisms by which cats resist infection with \textit{G. lamblia} remain to be determined.

Presently, the systematics of the genus \textit{Giardia} are not resolved (13). On the basis of morphometric studies (12), at least three \textit{Giardia} spp. are recognized, and those which infect cats and human beings are considered identical. If strict host specificity is assumed, over 40 species of \textit{Giardia} obtain (20). Thus, the \textit{Giardia} sp. which infects cats is regarded by some as a separate species, namely \textit{G. cati} Deschiens, 1925 (syn.: \textit{G. felis} Hegner, 1925) (9, 15).

Cross-transmission studies have been advocated as useful procedures in addressing problems of \textit{Giardia} systematics (21, 34). Carefully performed studies on the cross-transmission of \textit{Giardia} spp. among several rodent species revealed that some \textit{Giardia} spp. are highly host specific, whereas others are not (14). Other investigations have purported to show that, under experimental conditions, cats (11) and dogs (8, 10, 16, 29) are susceptible to \textit{G. lamblia} cysts or trophozoites from humans; the conclusions of these studies, however, have been questioned on methodological grounds (5, 20, 21, 34). Chief among the problems with these studies is the possibility that the dogs or cats used had previously been infected with and were harboring cryptic infections of their own, host-specific \textit{Giardia} spp. was not rigorously excluded.

In the interpretation of the results of the present study, factors intrinsic to the host animal and to the parasite must be considered. The demonstration of variations among individuals of a particular host species with respect to the level and duration of \textit{Giardia} sp. infection has suggested the existence of innate resistance and susceptibility factors (26, 27). Recent studies of \textit{G. lamblia} from human beings have indicated biochemical, antigenic, and virulence differences among various isolates (1, 6, 30). Thus, the results presented here do not necessarily exclude the possibilities that some individual cats may be highly susceptible to \textit{Giardia} sp. infective for humans and that species or strains of \textit{Giardia} exist which are equally infective for both cats and human beings.

On the basis of the data presented here, we conclude that, although cats may be transiently infected with \textit{G. lamblia} from humans, it is unlikely that significant environmental contamination by cats with \textit{G. lamblia} cysts infective for humans occurs. Furthermore, the results of this study imply that the \textit{Giardia} sp. infecting cats may be different from that which infects human beings.

**ACKNOWLEDGMENTS**

We are grateful to M. E. Haskins for providing animals and to J. L. Flinn for typing the manuscript.

**LITERATURE CITED**

5. Bemrick, W. J. 1984. Some perspectives on the transmission of...