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Parasites in Parks: The Zoonotic Potential Related to Socioeconomic Factors and Types of Pets

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Edmonton, Canada is a northern city with more than 100,000 registered pets with access to parks, playgrounds and off-leash areas. Our objectives were to determine the prevalence of zoonotic animal parasite infections in parks and relate this to numbers and types of pets and to socioeconomic factors. Also, we wished to compare the prevalence of the roundworm, *Toxocara canis*, to other cities in the world. More than 200 fecal samples from 50 different parks were analyzed using a fecal floatation concentration method. All parks had pet feces and 24% of samples (from 64% of parks) had eggs or cysts of parasites, including *Toxocara*, *Toxascaris*, *Taenia*, *Dipyllidium*, *Isospora*, and mites. Commonest parasites were ascaridoid nematodes (19% of sampls; 58% of parks) . Type of park and number of registered animals were not related with parasites but average household income and breed of dog was. In spite of its northern location, Edmonton was not unique in prevalence of *T. canis* and no global trends relating parasites to latitude were seen. City parks pose a threat of zoonotic infection and pet owners and veterinarians should be better informed. More effort in testing and deworming adult pets, particularly in economically disadvantaged areas of cities, should occur.

Keywords

Public parks, pets, parasites, zoonoses

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INTRODUCTION

Studies of the prevalence of dog and cat parasite eggs in soil or fecal samples in public parks have been conducted in cities around the world because of the potential for zoonotic infections (Tables 1 & 2). Edmonton Canada, (population near 1 million) is located further north (53 N) than any city where an analysis of parasite eggs in parks has been conducted. Summer temperatures average 20 C while winter temperatures of -20 C to -40 C occur. Because of the extreme climate, times required for nematode eggs to embryonate to infective N3 stages may be long, but cold and snow cover may result in an increased reservoir of preserved infective eggs.

The potential for transmission of parasites, including the ascarid nematodes *Toxocara canis* and *Toxascaris cati* to children is often underappreciated (Despommier 2003). Serological surveys indicate that many people (more than 20% of males and 15% females in southeastern counties of the US) have been exposed to these parasites and although usually asymptomatic, some children (about 1%) develop visceral larval migrans (VLM) and ocular disease (Congdon and Llyod 2011). Urban parks provide focal sites where pets, people, and urban wildlife interact.

Edmonton's pet population exceeds 100,000 registered dogs and cats. Pets are allowed on leash in most parks and designated off-leash parks also occur. At off-leash sites, biodegradable bags are provided and a bylaw (with a $100 fine for non-compliance) requires owners to pick up after pets. Parks usually include playgrounds with sand substrates, used for defecation by uncontrolled cats. Consequently, we were interested in discovering if the zoonotic potential for toxocariasis was greater in different types of parks – those with playgrounds *versus* off-leash. Also, we wished to know if zoonotic potential was related to numbers and types of registered pets, or associated with particular dog breeds in different parts of the city.

Although Edmonton is an affluent city, studies indicate that elsewhere socio-economic factors relate to toxocariasis (Congdon and Llyod 2011). Therefore, we asked if financial affluence was related to zoonotic potential at a finer geographic scale - we related park contamination levels to average household incomes. We also compared Edmonton to other cities to see if any trends in prevalence of ascarid contamination in parks occurred.

Our goals were to provide more information on the potential for transmission of pet parasites to humans and to make recommendations to municipalities and veterinarians to reduce risks of zoonotic infections, particularly toxocariasis, when people and pets use parks. We hypothesized that contamination would be greater in off-leash parks and in parts of the city with more registered pets because of greater numbers of animals and that less affluent city areas would have greater prevalence of parasites. Finally, we proposed that Edmonton would have a greater prevalence of ascarid nematodes than cities in more temperate latitudes.

METHODS

Study Design

Between May and July, 2011, 250 fecal samples were collected from 50 public parks. Because Edmonton includes hundreds of urban parks, not all could be sampled. We randomly selected parks based on two criteria: type of site (park, park with playground or off leash park) and city region (NW, NE, SW, SE) (Figure 1). At each park, five domestic animal fecal samples were collected. Samples were taken from different sites within each park to avoid multiple collections from one animal. Samples were frozen at -80 C for a minimum of 72 hours (Veit, *et al*., 1995), and stored at 4 C until parasitological examination. Only 210/250 was subsequently analyzed for parasites – the forty discarded samples were contaminated with fungus.

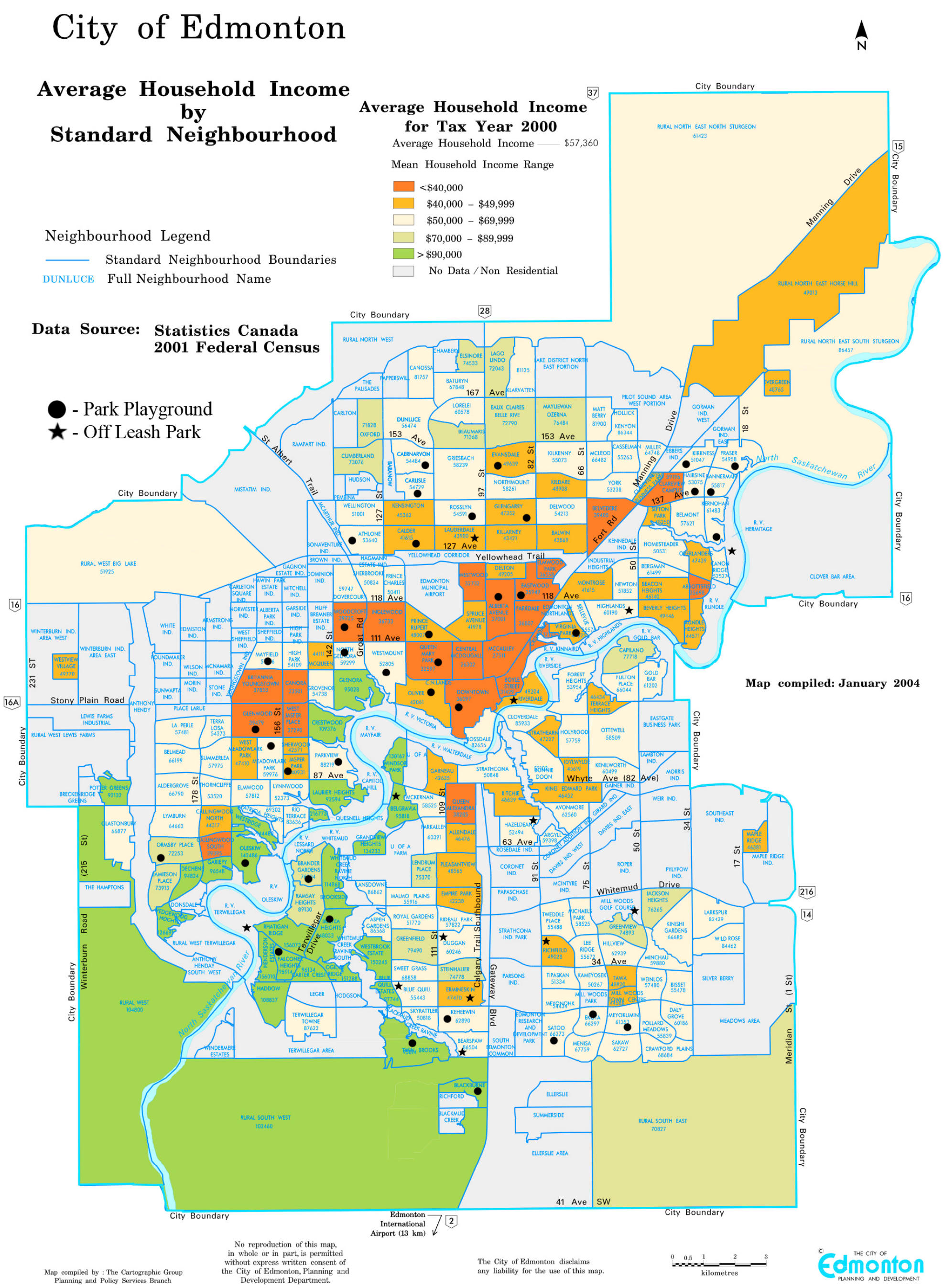

Figure 1. Map of Edmonton, Alberta, Canada with defined postal code areas and average household annual incomes. Quadrants (NE, NW, SE, SW) used for analysis were defined by the North Saskatchewan River and by major highways, which bisect the city. Numbers of registered pets and breeds of dogs as well as average annual household incomes were provided by the City of Edmonton per postal code area. Parks with playgrounds that were sampled are designated by dots, off leash parks by stars.

Parasitological Procedures

From each fecal sample, a 2-5 gm subsample was used for analysis. Fecal material was homogenized in a sieve (4 mm^2) and rinsed with 50 ml 1% TWEEN® (anionic detergent). TWEEN® emulsified the fats and separated helminth ova and protozoan cysts from solids. Fluid was poured into 50 ml tubes, covered in parafilm and centrifuged at 3600 G for 3 minutes to concentrate eggs and cysts. Supernatant was discarded and the precipitate was re-suspended in a 1.200 SG solution of sodium nitrate (FECOSOL®). Each tube was topped-up with sodium nitrate solution to form a positive meniscus; a 22mm X 22mm glass cover slip was placed on it, and it was centrifuged at 3600 G for 5 minutes. Afterwards, the cover slip was removed, placed on a microscope slide and examined. The procedure resulted in collection of helminth ova, some protozoan cysts (oocysts of *Isosopora* sp.) and mites that had passed through the host's digestive system. Pseudoparasites (pollen, fungal spores, and cysts of the earthworm parasite, *Monocystis* sp.) were also present. Parasite ova were measured and photographed for later identification.

Analyses

Patterns of association between parasites and ascarid nematode ova with types of parks, city areas (based on postal codes), types of pets, registered dog types for the ten most common breeds in Edmonton (based on postal code areas), dog size, total number of registered dogs, and average annual household income were analyzed using Pearson Chi-square, Likelihood Ratio Chi-square, and Fisher's exact tests. The ten most common registered dogs included 5 small breeds (<10 kg); shih-tsues, bichons, Chihuahuas, Yorkies, and Pomeranians, and 5 large breeds (>20 kg); Labrador retrievers, German shepherds, standard poodles, golden retrievers, and border collies. Prevalence of *T. canis* in Edmonton was compared to cities at different latitudes using linear and logistic regression analyses. The number and types of registered pets in different postal code areas of the city, and average annual household incomes were provided by the City of Edmonton.

RESULTS

All parks, playgrounds, and off-leash recreational sites sampled had pet feces. Thirty-two (64%) had parasites and 29 (58%) had *Toxacara* and *Toxascaris* (which we could not always reliably differentiate) eggs. Ascarid eggs were the most common parasites present, occurring in 41 of 210 samples (19.52%). No significant difference in prevalence of parasites in different park types occurred (Pearson Chi-square 2.893, DF = 2, P = 0.235). Sampled parks varied in area, but we did not group or differentiate sample parks based on this.

Parasites were not related to the abundance of pets in any part of Edmonton, but were more frequent in a city section that included the lowest average annual household incomes. A significant association occurred between the prevalence of ascarids and the northeast region of Edmonton (Pearson Chi-square 8.527, DF = 3, P = 0.036); standardized Pearson residuals indicated this sector has the highest prevalence, while the Southeast section of Edmonton had the lowest occurrence of parasites. Odds ratios describe the trend: the estimated odds of finding parasites in Northeast Edmonton were 5 times the estimated odds in the Southeast and 2.75 times the estimated odds of the Southwest. A significant association occurred between parasite prevalence and average annual household income (Pearson Chi-square 6.849, DF = 3, P =

0.033). Northeast Edmonton, with the lowest income, had the most contamination. Standardised Pearson residuals indicate that regions with large average incomes (more than $75,000 Canadian) have the smallest prevalence of parasites. We fit linear logit models (logistic regression) for prevalence of parasites on average income. The odds of finding parasites decrease by 0.77 times with each $10,000 increase in average income, and the odds of finding *Toxocara* decrease by 0.66 times with each $10,000 increase in average income. No differences were found between the numbers of registered pets or dog size and park contamination, - in fact, the part of Edmonton with the lowest number of registered pets had the highest sample prevalence of parasites.

Parasite prevalence in each part of Edmonton was compared to dog breeds by grouping them categorically depending on total number of dogs of each breed. Only 2 of the 10 commonest breeds showed any relationship: golden retrievers (Pearson's chi-square 4.008, DF = 2, P = 0.045); and Labrador retrievers, (Pearson Chi-square 7.415, DF = 2, P = 0.025), however, results were sensitive to the choice of groups.

Finally, we compared results of our study to 30 others from around the world to investigate any relationship between prevalence of ascarids and latitude. No significant linear trend (R^2 = 2.3%) was detected and logistic regression did not reveal any trend either (Figure 2, Table 1).

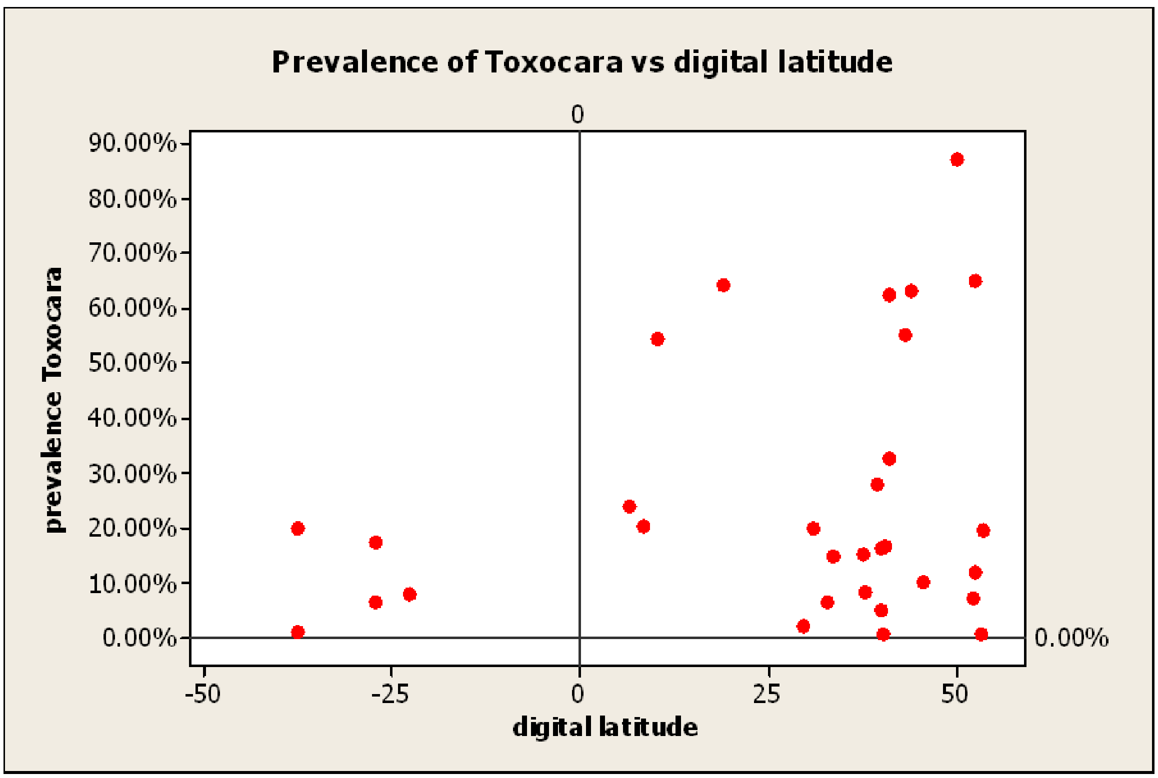

Figure 2. Percent prevalence of *Toxocara canis* eggs in soil and fecal samples from public parks reported from published studies (including this study) from around the world. The x-axis is digital latitude.

Table 1. Percent prevalence of *Toxacara canis* eggs in parks reported from around the world.

Study	Location	Digital latitude	% Prevalence
Akdemir, 2010	Kutahya, Turkey	39.42	28.00%
Avcioglu & Balkaya 2011	Erzurum. Turkey	39.83	5.00%
Avcioglu, et al., 2008	Ankara, Turkey	39.92	16.30%
Boreham & Capon. 1982	Brisbane, Australia	-27.48	17.50%
Carden et al. 2003	Melbourne, Australia	-37.78	1.10%
Cielecka, et al. 2006	Warsaw, Poland	52.25	7.00%
Dado, D. et al., 2012	Madrid, Spain	40.38	16.70%
Devera, et al. 2008	Bolivar City, Venezuela	8.3	20.40%
Dubna, et al. 2007	Prague, Czech Rep.	40.92	62.50%
Duwel, D. 1984	Frankfurt, Germany	50.03	87.00%
Emehelu & Fakae. 1986	Nsukka, Nigeria	6.42	24%
Franzco, et al. 2003	Melbourne, Australia	-37.78	19.80%
Ghadirian et al. 1976	Montreal, Canada	45.5	10.00%
Gillespie, et al. 1991	London, U.K.	41.02	32.60%
Habluetzel, et al. 2003	Marche Region, Italy	43.88	63.30%
Harbinder, S. et al. 1997	Ludhiana, India	30.92	19.71%
Martinez-Moreno, et al. 2007	Cordoba, Spain	37.83	8.40%
Matsuo & Nakashio. 2005	Sapporo, Japan	43.08	55%
Mizgajska & Jarosz. 2007	Poznan, Poland	52.42	65.00%
Mizgajska & Luty. 1998	Poznan, Poland	52.42	12.00%
Motazedian, et al. 2006	Shiraz, Iran	29.63	2.20%
Nunez, et al. 2009	Tulyehualco, Mexico	18.8	64.30%
O'Lorcaine 1994	Dublin, Ireland	53.33	0.56%
Paquet-Durand, et al. 2007	Costa Rica	10	54.50%
Paul, et al. 1988	Urbana, Ill.	40.1	0.56%
Santarem, et al. 1998	Botucatu, Brazil	-22.85	7.80%
Tavassoli, et al. 2008	Urmia City, Iran	37.53	15%
Teixeira, et al. 2008	Concordia City, Brazil	-27.25	6.30%
Tinoco-Garcia, et al. 2007	Mexacali, Mexico	32.63	6.30%
Zibaei, et al. 2010	Khorram, Iran	33.48	14.90%
This study	Edmonton, Canada	53.57	19.52%
Average			24.62%

DISCUSSION

Like most cities, the dog and cat population in Edmonton is huge with more than 100,000 registered companion animals plus unknown numbers of unregistered and feral animals but pet density may be not as large as in some cities due to the large geographic area the city occupies. Pets in public parks are common and their defecation presents a risk of zoonotic infections. Human toxocariasis occurs when people contact contaminated soil and ingest eggs. Infections are under-diagnosed because they are often asymptomatic, but a large serodiagnostic study in the United States for *Toxocara canis* showed average infection levels of 14% (Congdon and Lloyd 2011). Although infection tends to increase with age, children are particularly vulnerable and toxocariasis may present as visceral larva migrans or ocular disease (Despommier 2003). Ascarid nematode infections may result in generalized symptoms such as asthma, abdominal pain, dermatitis and neurological lesions that cause delays in cognitive development (Nathwani *et al*. 1992; Nelson *et al*. 1996; Magnaval *et al*. 1997; Cooper 2008).

City planners have a dilemma trying to control park use for a variety of purposes – children's play, sports and recreation, and for owners to exercise pets. Management methods for regulating multi-purpose use include limiting pets (on leash) to certain parks, providing off-leash areas, and (other than pregnant animals) are at small risk of developing patent infections, unless they are prohibiting pets from some parks. Other tools include pet cleanup bylaws and provision of waste bags and receptacles where pets are allowed.

Despite these approaches, all parks in Edmonton contained animal feces and there was a high level of contamination (64%) with parasites. Eggs of potentially zoonotic ascarid nematodes (*Toxacara canis* and *Toxascaris cati*) were found in 58% of the parks. The type of park made no difference; contamination was equally likely to occur in parks with playgrounds where the potential for infection of children is highest, as in off-leash parks. We suggest that cities consider providing pet waste bags and more pet bylaw signage in all types of parks that allow pets, not just in off leash areas.

We hypthesized that areas of Edmonton with greater numbers of registered animals would have more contaminated parks; but this was not the case. Perhaps no relationship between the number of pets and their use of parks occurs, or possibly some city areas are more likely to have unregistered, or feral animals. Also, pets in some city areas may receive better veterinary care, including regular examinations and anthelminthic treatment. That pets are more likely to be registered and get more veterinary care was supported by the relationship between socio-economic status (indicated by average household income) and prevalence of parasites. Affluent areas had lower parasite prevalence in parks (even with more registered pets) and the highest level of contamination occurred in the area with the lowest annual incomes. Parks here also had more pet feces. The serological study of Congdon and Lloyd (2011) showed a positive relationship between poverty and *Toxocara* infection rate – families with income below the poverty threshold had an elevated risk of infection.

While income was related to parasite contamination, pet type was also a factor. No relationship was found between contamination and dog size, but two breeds – golden retrievers and Labrador retrievers were significantly associated with contaminated parks. Both are active, outdoor retrieving dogs that tend to mouth items. Perhaps because of their activity patterns, they get exposed to more helminth ova or are more likely to find and ingest paratenic hosts (like rodents) infected with *Toxocara canis*.

Edmonton, at 53 N latitude, experiences severe annual changes in temperature but was not unusual with regards to the prevalence of samples containing ascarid eggs (19.52% *vs.* a world average of 24.62%, see Table 1, Figure 2). Eggs are thick-shelled and can survive 6 years in soil (Llyod 1998). Cold and UV-protective snow cover may mitigate killing effects of solar radiation. Comparisons with other studies are confounded because results are presented that do not differentiate between individual soil or fecal samples *versus* number of parks sampled. Also, some studies were not clear regarding whether only Toxocara canis eggs, or all types of parasite ova, were being counted. Different researchers used a variety of techniques to look for parasite ova. However, it appears that there is no overall relationship between latitude and prevalence of ascarid ova in parks.

Often young dogs and cats are infected with ascarids acquired trans-placentally (Bowman 2009). Older animals have juveniles (N4) in tissues that can be activated to form reproductive adults. Veterinarians routinely deworm young pets, but anthelminthic treatment of older animals is sporadic. Standard practice suggests that immunologically competent adults exposed repeatedly to many embryonated eggs or ingest paratenic hosts. Our study indicates that there is a zoonotic potential for transmission of ascarid parasites. Pets in impoverished areas (even within an affluent city) probably do not receive sufficient veterinary care as adults. Veterinary practice should include regular deworming of older animals. Cities should better educate citizens with the necessity of cleaning up after pets in parks to protect children and pets. Cities can reduce the risk of zoonotic infections, like toxocariasis, by providing more signage explaining the transmission and risks of infection and by reinforcing pet bylaws and penalties for non-compliance. Signs, disposal bags and waste receptacles should occur in any park where pets are allowed, not just at off leash parks. These measures are especially important in city areas where people are less advantaged. Finally, veterinarians should be aware that adult pets may have patent infections of helminths and should recommend regular deworming.

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