Accepted Manuscript

Title: ontamination of the hair of owned dogs with the eggs of *Toxocara spp*.

Authors: Jason Devoy Keegan, Celia V. Holland

PII: S0304-4017(10)00343-2
DOI: doi:10.1016/j.vetpar.2010.06.010
Reference: VETPAR 5360

To appear in: *Veterinary Parasitology*

Received date: 23-3-2010
Revised date: 2-6-2010
Accepted date: 7-6-2010

Please cite this article as: Keegan, J.D., Holland, C.V., ontamination of the hair of owned dogs with the eggs of *Toxocara spp*., *Veterinary Parasitology* (2008), doi:10.1016/j.vetpar.2010.06.010

Contamination of the hair of owned dogs with the eggs of *Toxocara spp*.

Jason Devoy Keegan* and Celia V. Holland

Parasitology Research Group, Department of Zoology, University of Dublin, Trinity College, Dublin 2, Ireland.

*Corresponding Author: Jason Devoy Keegan, Tel: +353879723410, Fax: ++353 (0)1 6778094, email: devoykej@tcd.ie

Abstract:

Toxocara canis is one of the most common gastrointestinal helminthes of dogs. Humans can become infected through ingestion of infective eggs, Infection often causes few symptoms but in rare cases blindness can occur. It is generally accepted that human infection is caused as a result of direct contact with contaminated soil. However, recently, the eggs of *Toxocara spp*. have been found in the hair of dogs, implicating them as a possible additional route of transmission. The aim of this study was to assess the extent to which the hair of owned dogs was contaminated with the eggs of *Toxocara*. Samples were taken from the head, neck, back and anus of 184 dogs. Eggs were recovered from the hair using a previously standardised detection method. Eggs were found on the hair of 8.8% of the sampled dogs. None of the eggs found were embryonated. There was no significant difference found between the numbers or prevalence of eggs taken from the head, neck, back and anus. Older dogs were significantly more likely to possess eggs on their hair than those under one year of age. The low prevalence and the lack of potentially infective embryonated eggs suggests that direct contact with well cared for owned dogs poses a low risk of infection with *T. canis.*

Introduction

T. canis is a parasitic, ascarid nematode considered to be one of the most common gastrointestinal helminths of domestic dogs and other canids worldwide (Parsons 1987; Overgaauw 1997). Infected dogs can shed large numbers of eggs into the environment causing infection in other dogs and in paratenic hosts including small mammals and humans (Gillespie 1988; Holland & Smith, 2006).

Human infection with *Toxocara* can manifest itself as three clinical syndromes; Ocular Larva Migrans (OLM); Visceral Larva Migrans (VLM); and covert Toxocariasis (Magnaval & Glickman, 2006). Common symptoms of these syndromes include asthma, fever, coughing, and abdominal pain but in some cases visual impairment or even blindness can occur (Magnaval & Glickman, 2006; Taylor, 2006). Serological tests have shown that exposure to infection in humans can be quite high, with children being at a higher risk than adults. Recently, Hotez & Wilkins (2009) described Toxocariasis as the most common helminth infection in the United States and a highly prevalent infection in many developing countries. Serological data may support these claims with estimations of *Toxocara* seroprevalence in children ranging from 4-41% in developed countries and as high as 86% in developing countries (Taylor & Holland, 2001).

Contact with contaminated soil is considered to be the primary route of transmission of *Toxocara* in humans (Jacobs *et al.,* 1977; Glickman, 1993; Holland, 1997; Overgaauw, 1997). This is due in part to the fact that eggs require a period of time under appropriate environmental conditions to develop to infectivity (Glickman & Schantz, 1981). The risk of infection has also been seen to be elevated in people who suffer from pica, a compulsion to eat mainly nonnutritive items, and particularly geophagia or soil-eating (Glickman & Schantz 1981; Holland, 1995; Mizgajska & Uga 2006).

Recently, infective eggs have been found in the hair of dogs suggesting that direct contact with the coat of a contaminated dog could be an additional route of transmission (Wolfe & Wright 2003, Roddie *et al*., 2008a, Aydenizoz-Ozkayhan *et al.*, 2008). The presence of embryonated eggs in some of these hair samples further implicates direct contact as a possible transmission route. The studies carried out by Roddie *et al*., (2008a) and Wolfe & Wright (2003) represented a mixture of stray and owned dogs and so the numbers of eggs detected could be attributable to the lack of care, in the form of anthelminthic treatment and grooming, given to the stray animals sampled. However, Aydenizoz-Ozkayhan *et al.*, (2008) found higher levels of embryonating eggs on the hair of the dogs in their survey focusing solely on pet animals. In contrast to these results Overgaauw *et al*., (2009) failed to find any embryonated eggs on the hair of the owned dogs in their Dutch survey.

To further investigate the potential for transmission via direct contact, the current study focused upon owned dogs, including both adults and puppies, that attended veterinary clinics or grooming parlours and were therefore considered to be representative of a well looked after population. Hair samples were also taken from a range of locations on the dog's body including those often touched by owners. Factors that may have influenced the presence of eggs on hair, such as age, sex and coat type, were also investigated.

Materials and Methods

Sample collection and egg detection

Dog hair samples were supplied by 3 dog grooming parlours, 10 veterinary practices, 2 boarding kennels and interested pet owners between March and December 2009. All of the grooming parolurs and eight of the veterinary practices were located in the greater Dublin area. The remaining two veterinary practices were located in Preston and Milton Keynes in the UK. The boarding Kennels involved were located in Co. Longford and Co. Cork. Individuals provided samples from Co. Dublin and Co. Cork. Instructions, a hair thinning coat rake and sampling bags were sent to each of the above locations. The samples were taken from four different locations on the dog's body: the head, neck, back, and perianal region. The majority of samples were taken using a coat rake. This device was used like a brush. If the coat rake did not yield enough hair, a hair thinning scissors was used. The equipment was washed thoroughly with water between each hair sample taken. Each of the four hair samples taken from the dog were placed in individual re-sealable bags. The name, age, sex, breed, coat type and home location of each dog was recorded. Each dog was also assigned an ID number. The hair samples were then refrigerated at 4°C until processed. Eggs were recovered from the hair using the technique described by Overgaauw *et al*., (2009). Only the ID of the sample was known during the egg recovery procedure.

Statistical analysis

Data were expressed as the prevalence of *Toxocara* eggs on the hair ± 95% C.I., the mean eggs per gram of hair (e.p.g) ± S.D and median e.p.g ± Interquartile range (IQ). The factors affecting the prevalence of eggs in hair, shown in Table 1., were analysed by maximum likelihood techniques based on log linear analysis of contingency tables using the software package PASW

(Version 18.0.0.). An initial full factorial model incorporated the following factors: age (2 levels, less than or greater than 1 year of age), sex (2 levels, male or female), coat type (2 levels, single or double) and coat length (2 levels, long or short). Then, using a backward selection procedure beginning with the most complex model, all possible interactions were incorporated and those combinations that did not contribute significantly to explaining variation in the data were eliminated in a stepwise fashion beginning with the highest-level interaction. This resulted in a minimum sufficient model, for which the likelihood ratio of χ^2 was not significant, indicating that the model was sufficient in explaining the data. The remaining terms in the final model are summarised together with the likelihood ratio for the final model in the text.

Results

A total of 726 hair samples were examined from 182 dogs over a period of 10 months. *Toxocara* eggs were found on the coats of 16 dogs, with a prevalence of 8.8% (C.I. ± 4.6, 15.7). A total of 26 eggs were found, two of which were not viable, twenty-three were unembryonated and one was embryonating. The overall mean e.p.g found was 0.111 ± 0.995. Taking only contaminated dogs into account, the mean epg was 4.24 ± 4.62 and the median number found was 2.17 ± 5.92. The numbers of eggs found on the different parts of the dogs coat are shown in Table 2.

Log linear analysis revealed that there was a significant effect of age on the prevalence of *Toxocara* eggs in hair (χ^2_1 = 8.410, p= 0.004). The goodness-of-fit of the overall model was given by the likelihood ratio χ^2_{16} =10.09 (*P*=0.86), indicating the model was sufficient in explaining the data. There was no significant effect of each host factor on the median number of eggs per gram found (Table 2).

Discussion

We have found the eggs of *Toxocara* in 8.8% (C.I. ± 4.6, 15.7). of the owned dog hair samples. This result is close to the 12.2% prevalence found by Overgaauw and colleagues, (2009), who carried out a survey on an owned dog population in the Netherlands. A comparable number of owned dogs were sampled and the same egg recovery method was used. The prevalences found for both our study and the Dutch investigation are lower than those that would be expected based on previous work (Wolfe & Wright, 2003; Roddie *et al*., 2008a; Aydenizoz-Okayhan *et al*., 2008). In the Turkish study, a higher prevalence of 22% in an owned population of dogs was found (Aydenizoz-Okayhan *et al*., 2008). However, a smaller sample size derived from a single veterinary practice detracts from its findings. Wolfe and Wright (2003) and Roddie *et al*., (2008a) found higher prevalences of 25% and 67% of dogs harbouring eggs in their coats, respectively. These higher prevalences may be explicable by the focus upon stray dogs in the two studies with a mixture of stray and owned dogs being sampled by Wolfe and Wright (2003) and only stray dogs by Roddie *et al*., (2008a). The higher prevalence in stray dogs is most likely attributable to the lack of anthelminthic treatment and grooming given to these animals.

The results of the present study suggest that older owned dogs are more likely to harbour eggs on their hair than dogs less than one year of age. This was similar to the findings of Wolfe and Wright (2003) where fourteen of the fifteen infected dogs were over the age of one. A similar trend was shown by Overgauuw *et al*., (2009), who also found older dogs were more often contaminated with eggs, the average age of infected dogs being 6.5 years. Aydenizoz-Okayhan *et al*., (2008) found no significant effect of age on the number of eggs per gram (e.p.g.) of hair, however 82% of dogs were under the age of one. In contrast, Roddie et al., (2008a) found a significant effect of age on the prevalence of eggs in hair with 100% of stray puppies being infected as opposed to only 56% of adult dogs. This difference between stray and owned puppies may indicate the effectiveness of current anthelminthic treatment regimes in owned dog populations.

Without anthelminthic control, self-contamination, with eggs coming from an active intestinal infection, could be expected to be high. Roddie *et al*., (2008a) showed a strong correlation between worm burden in the stray puppies and the numbers of eggs in their hair. Patent infections can develop in puppies as young as sixteen days old and spontaneous loss of infection tends to occur between 3 and 6 months (Lloyd, 1993). As such, self-contamination in puppies might be expected to be highest in dogs ageing from approximately 2-26 weeks. None of the dogs in this study within that age range (n=42) had contaminated coats. However, most of these hair samples were taken from litters intended for training as guide dogs for the blind, who were a product of a breeding program. Only five dogs between the ages of 2 and 26 weeks were not part of this program and four of those were from the same litter. The European Scientific counsel for companion animal parasites (ESCCAP) advise starting treatment at 2 weeks of age. Treatment to this extent would presumably minimise the opportunity for adult *T.canis* worms to develop, reducing the chances for contamination of the dogs coat with potentially infective eggs. Self-contamination could still be an important factor in owned puppies managed under less stringent anthelminthic regimes.

Interestingly, an association between intestinal worm burden and egg densities in hair has not been demonstrated in adult dogs (Roddie *et al*., 2008a; Overgaauw *et al*., 2009). This indicates that environmental contamination could be, at least, in part responsible for the presence of eggs on the coats of adult dogs. In Ireland, dogs, cats and foxes are responsible for the presence of *Toxocara* eggs in the environment (Roddie *et al*., 2008b). Wolfe and Wright (2004) also found the eggs of other intestinal parasites, such as *Nematodrius battus,* that are not parasitic within dogs in some hair samples. Future work should consider PCR techniques in order to determine the levels of *T.canis* and *T.cati* found providing further information on the role of environmental contamination. In the present study, the highest numbers of eggs were found on the back, with the lowest numbers being found in the peri-anal region. This trend could be explained by the dog's playing behaviour resulting in increased soil contact (Overgaauw *et al*., 2009). Other behaviours such as scent rolling could also be responsible for increased contact with soil. Dogs are often found to roll in strong smelling substances, including faeces, covering themselves in the scent (Harrington & Asa, 2003). Due to the risk of infection from various diseases for young puppies, Irish dog owners are advised not to walk their dogs publicly until their final vaccination at approximately 3 months of age (Irish Blue Cross). If environmental contamination is attributable to higher egg densities in owned dogs, the low numbers found in young dogs may be explained by the lack of opportunity for a well cared for puppy to become contaminated in public spaces.

This survey found no embryonated eggs in the hair of owned dogs. This finding is again similar to that of Overgaauw *et al*., (2009) who also found no embryonated eggs. Differences between these two studies and previous work carried out by Roddie *et al*., (2008a) and Wolfe & Wright (2003) may again be attributable to the focus on stray dogs. However, Aydenizoz-Okayhan *et al*., (2008) did reveal comparatively high levels of embryonated eggs in their study focusing on owned dogs (Table 3).

Our findings along with those of Overgaauw *et al*., (2009) suggest that direct contact with well cared for owned dogs represents a very low risk, of infection with *Toxocara.* Differences in prevalences among young, owned dogs and young, stray dogs may be an indication of the success of current anthelminthic regimes in treating our pet animals and only reinforces their importance.

Acknowledgements

We thank Bayer Animal Health GmbH for funding the research and Roland Schaper for his support. We would also like to thank the following for collecting samples: Irish Professional Dog Groomers Accociation; the ISPCA; the Irish Guide Dogs for the Blind; Anicare; Dunsaughlin veterinary hospital; Kilmacud veterinary hospital; The Priory veterinary hospital; Bairbre O'Malley veterinary hospital; Marie-Lousie veterinary hospital; and Emer Butler. We thank Ian Wright for sample collection and helpful comments. We also thank Professor Jerzy Behnke for statistical advice concerning the Maximium Likelihood model.

References

Aydenizoz-Ozkayhan, M., Yagci, B.B. and Erat, S. (2008). The investigation of *Toxocara canis* eggs in coats of different dog breeds as a potential transmission route in human toxocariasis. *Veterinary Parasitology* **152(1-2)**, 94-100.

Gillespie, S.H. (1988).The epidemiology of *Toxocara canis*. *Parasitology Today* **4**, 180-181.

Glickman, L.T and Schantz, P.M. (1981) Epidemiology and pathogenesis of zoonotic toxocariasis. *Epidemiological Reviews* **3**, 230-250.

Glickman, L.T. (1993) The epidemiology of human toxocariasis. In *Toxocara* and Toxocariasis, Clinical, Epidemiological and Molecular Perspectives. Eds Lewis, J. and Maizels, R. London, Institute of Biology and the British Society for Parasitology. pp 3-10.

Harrington, F.H, & Asa, C.S. (2003) In Wolves: behavior, ecology, and conservation. Eds Mech, D.L., & Boitani, L University of Chicago Press, pp 86.

Holland, C.V. and Smith, H.V., (2006). *Toxocara*: the enigmatic parasite.,CABI Publishing pp 301.

Holland, CV, O'Lorcain, P, Taylor, MRH and Kelly A. (1995). A. Sero-epidemiology of toxocariasis in schoolchildren. *Parasitology* **110**, 535-545.

Holland, C.V., O'Connor, P., Taylor, M., Hughes, G., Girdwood, R. and Smith, H. (1991) Families, parks, gardens and toxocariasis. *Scandanavian Journal of Infectious Diseases* **23**, 225-231.

Hotez, P.J. and Wilkins, P.P., (2009). Toxocariasis: America's Most Common Neglected Infection of Poverty and a Helminthiasis of Global Importance? *Neglected Tropical Diseases*. **3(3)** 1-4.

Jacobs, D., Woodruff, A. and Prole, J (1977) *Toxocara* infection and kennel workers. *British Medical Journal* **1**, 51.

Lloyd, S., (1993) *Toxocara canis:* the dog. In *Toxocara* and Toxocariasis, Clinical, Epidemiological and Molecular Perspectives. Eds Lewis, J. and Maizels, R. London, Institute of Biology and the British Society for Parasitology. pp 841-854.

Magnaval, J.F., Glickman, L.T. (2006) Management and treatment options for human toxocariasis.
In *Toxocara*: the enigmatic parasite Eds. Holland, C.V. and Smith, H.V. CABI International, pp. 113-126.

Mizgajska-Wiktor H. and Uga, S. (2006) Exposure and environmental contamination. In *Toxocara*: the enigmatic parasite. Eds Holland C.V. and Smith H.V. CABI International, pp 211-227.

Overgaauw, P.A.M. (1997) Aspects of toxocarosis in dogs and cats. *Critical Reviews in Microbiology.* **23(3)**, 233-251.

Overgaauw, P.A.M., van Zutphen, L., Hoek, D., Yaya, F.O., Roelfsema, J., Pinelli, E., van Knapen, F., Kortbeek, L.M. (2009) Zoonotic parasites in fecal samples and fur from dogs and cats in The Netherlands. *Veterinary Parasitology*. **163(1-2)**, 115-122.

Parsons, J.C. (1987) Ascarid infections of cats and dogs. *Veterinary Clinics of North America* **17**, 1307-3.

Roddie, G., Stafford, P., Holland, C.V. and Wolfe, A. (2008a) Contamination of dog hair with the eggs of *Toxocara canis*. *Veterinary Parasitology* **152**, 85-93.

Roddie, G., Holland, C.V., Stafford, P. and Wolfe, A. (2008b) Contamination of fox hair with the eggs of *Toxocara canis*. *Journal of Helminthology* **00**, 1-4.

Taylor, M.R.H., Holland, C. (2001) Toxocariasis. In: Principles and practice of clinical parasitology. Eds. Gillespie S.H., Pearson R.D. Wiley, pp. 501-522.

Taylor, M.R.H. (2006) Ocular Toxocariasis. In *Toxocara*: The enigmatic Parasite. Eds. Holland, C.V. and Smith, H.V. CABI International, pp.127-144.

Wolfe, A. and Wright, I.P., (2003) Human toxocariasis and direct contact with dogs. *Veterinary Record* **152**, 419-422.

Wolfe, A and Wright, I.P., (2004) Parasitic nematode eggs in fur samples from dogs. *Veterinary Record* **154**, 408-409.

Table 1. Summary of sample sizes for each host characteristic

Variable	Categories	Sample SIze
Age	< 1 year	65
	> 1 year	117
Sex	Male	88
	Female	94
Coat Type	Single	78
	Double	104
Coat Length	Short	92
	Long	90
Source	Dog Grooming Parlour	53
	Veterinary Practice	85
	Individual Dog Owner	5
	Boarding Kennel	39

Table 2. Summary of egg numbers taken from each coat sample of the contaminated dogs.

	Head	Neck	Back	Anus	Total
No. of egg positive hair Samples	5	4	7	3	19
Total Eggs found	5	4	12	5	26
Mean e.p.g per location on coat	2.95 ± 2.42	2.92 ± 2.92	6.83 ± 6.54	2.1 ± 1.03	n/a
Medain e.p.g per coat loation	1.73 ± 3.6	1.93 ± 5.19	4.85 ± 13.7	2.17 ± 2.07	n/a

Table 3. Comparison of embryonation rates of eggs found in contaminated hair.

Reference	Location	Embryonated Eggs	Total eggs	% Embryonated
Wolfe & Wright (2003)	UK and Ireland	3	71	4.2
Roddie *et al*., (2007)	Ireland	120	39,120	0.03
Aydenizoz-Ozkayhan *et al.*, (2008)	Turkey	5	72	8.06
Overgaauw *et al.*, (2009)	The Netherlands	0	not given	0
This Study	UK and Ireland	0	26	0