Toxocarosis in humans: how much of a problem is it in the UK?

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Abstract

Toxocara canis (from dogs) is recognised as a potential cause of human toxocarosis, but *Toxocara cati* (from cats) and other species (eg, *Toxascaris leonina* found in foxes) are also possible causes. Most colonisation with *Toxocara* species does not lead to symptomatic infection in well-cared for adult animals; young and debilitated animals are at greater risk. Humans can acquire infection from infected animals, for example, via soil contaminated with faeces; however, most human infections are asymptomatic, with symptomatic infection being very rare in the UK. The risk of human infection is reduced by measures such as hand washing and responsible disposal of dog faeces. Some organisations recommend regular prophylactic treatment of pet dogs and cats. However, there are concerns that some parasiticides are contaminating the environment. As an example of a One-Health problem there is a potential conflict between the needs of animal health, human health and the health of the wider ecosystem. Also, considering that only about 5% of non-juvenile household dogs shed *Toxocara* eggs at a given time, it has been questioned whether it is worthwhile to invest in frequent blind treatments. British veterinary organisations have suggested less frequent treatment may be more appropriate and should be based on individual risk assessment and faecal examinations for worms rather than blanket regular prophylactic treatment, which could reduce the impact of parasiticides on the environment without greatly increasing the risks to animal or human health.

Key learning points

- Parasiticides used in veterinary practice may contaminate the environment, with effects on ecosystems.
- It is important to consider the risks of toxocarosis to individual animals, the risk of transmission of infection to humans and the environmental effects of parasiticides before using such treatment.
- Humans can acquire infection from infected animals but symptomatic infection is rare in the UK.
- A joint policy statement from the British veterinary organisations advocates that veterinary professionals should always undertake a benefit/risk assessment of each individual case to determine the choice of anthelmintic and frequency of administration.
- Other preventive measures are important and include reducing the risk associated with dog fouling by removing faeces and disposing of them responsibly.

Introduction

Toxocarosis is the parasitic infection transmitted from animals to humans (zoonosis) caused by the larvae (immature worms) of two main species of *Toxocara* roundworms: *Toxocara canis* from dogs and *Toxocara cati* from cats, and other species (eg, *Toxascaris leonina* found in foxes).[1 2] Although *T. canis* is better recognised as a cause of human toxocarosis, *T. cati* should not be overlooked.[3] However, parasiticides used for deworming have a high cost (when considering over 10 million dogs and 11 million cats in the UK and multiple treatments), potentially contaminate the environment and are harmful to a wide range of invertebrates, which could be highly detrimental to wildlife, ecosystems and in turn human health.[4 5] The Royal College of Veterinary Surgeons' code of conduct states that 'Veterinary surgeons must seek to ensure the protection of public health and animal health and welfare and must consider the impact of their actions on the environment'.[5] Here, we consider the lifecycle of *Toxocara*; its routes of transmission from animals to humans; risk factors for infection among animals and humans; clinical manifestations; the prevalence of infection in the UK; and measures to prevent or reduce the risk of infection.

Lifecycle of *Toxocara*

The US Centers for Disease Control and Prevention states that puppies usually acquire *T. canis* from their mother in utero or from her milk.[6] The larvae mature in the puppy's intestine; when the pup is 3 or 4 weeks old, the worms begin to produce large numbers of non-infective (unembryonated) eggs that are excreted in faeces, then it takes about 2–4 weeks for infective (embryonated) larvae to develop in the eggs.[6] *Toxocara* eggs can survive in the environment for months or even years under the right conditions.[6 7] Embryonation and survival of *Toxocara* eggs are most likely at temperatures of 20–30°C and in moist soil.[8]

After ingestion by a definitive host (eg, dog, cat or fox), directly from the contaminated environment or indirectly through ingestion of other (paratenic) hosts (eg, rabbits, pigs, cattle, poultry, wild birds or rodents), the infective eggs hatch and larvae penetrate the gut wall and migrate into various tissues where they encyst (dormant larvae).[1] In younger animals, the larvae migrate through the lungs and bronchial tree, where they are coughed up and swallowed; adult worms develop and lay eggs in the small intestine.[6] Again, eggs of *Toxocara* spp are shed in the faeces of the definitive host.[1 9 10] In older dogs, patent (egg-producing) infections can also occur, but larvae usually become arrested in tissues.[6] These are reactivated in bitches during late gestation.[6]

In cats, *T. cati* larvae can be transmitted during suckling to kittens if the mother is infected during gestation, but larval arrest and reactivation in tissues do not appear to be as important as in *T. canis*.[6]

Routes of transmission from animals to humans

Toxocara spp has a faecal-oral transmission route.[8] In a modelling study (excluding animals younger than 6 months) in the Netherlands (a country stated to be free of stray dogs), pet dogs accounted for 39% of the overall egg output, followed by stray cats (27%), household cats (19%) and foxes (15%).[9] In urban areas, egg output was dominated by stray cats (81%).[9]

Humans are accidental hosts who become infected by ingesting infective eggs by swallowing dirt that has been contaminated with animal faeces that contain infectious *Toxocara* eggs (eg, in gardens, sandpits and playgrounds).[1 8 11]

Transmission is also possible through direct contact with pets due to *Toxocara* eggs in pet hair,[8] although a very low number of embryonated eggs are detected on host hair, particularly among adult dogs that are owned and well cared for, with higher numbers among puppies and stray dogs.[12–14] Only embryonated eggs are infective, so the environment is a more likely source of infection.[10]

Although it is rare, people can also become infected from eating undercooked or raw meat containing *Toxocara* larvae from an infected animal such as a lamb or rabbit, or from contaminated raw vegetables.[1 8] For example, a recent publication reported the presence of *Toxocara* eggs on around 2% of lettuces from community gardens in England where cats, dogs and foxes had been sighted.[15]

Toxocarosis is not spread by person-to-person contact.[6]

Risk factors for infection

Animals

Among animals, infection rates are higher for:

- Puppies, kittens, pregnant bitches, lactating bitches and queens and geriatric animals.[16]
- Stray cats, working and rural dogs than pet cats and dogs.[17]
- Dogs and cats that are left outside or with unrestricted access to the outdoors and allowed to eat other animals.[6 16]
- Animals kept in kennels, shelters or breeding stations, living with other dogs or cats, or living in or travelling to different geographic areas.[16]

Humans

Among humans, infection rates are higher for:

- People living in hot humid regions where eggs survive better in the soil.[6 8]
- People with low levels of education, living in poverty, or in areas with a lower Human Development Index (a composite measure of life expectancy, education and national income), poor sanitation and hygiene.[8 18–20]
- Those who consume raw meat or drink untreated water.[8]
- Owners of dogs or cats.[1]
- Young children, those who play in sandpits or eat soil.[1 18 21]
- People with poorer cognitive function and epilepsy possibly due to pica behaviours or falls.[22–26]

Clinical manifestations

Animals

Among animals, most pets show no clinical signs of infection with *Toxocara*, but some may vomit, stop eating, or lose weight.[6] Rarely, heavy infections in young puppies and kittens may be fatal.[6]

Humans

Among humans, after ingestion, the eggs hatch and larvae penetrate the intestinal wall and circulate in blood to the liver, heart, lungs, brain, muscle or eyes.[1] While the larvae do not develop further in these sites, they can cause local inflammation and damage leading to clinical toxocarosis.[6 27] Host genetics and innate or acquired immunity determine susceptibility or resistance to parasite infection.[28]

In most human cases, *Toxocara* infections are not serious, and many people, especially adults infected by a small number of larvae, may be asymptomatic, or have mild or non-specific symptoms that are undiagnosed.[27 29] Serological testing for *Toxocara* antibody is available, although a positive test does not necessarily correlate with any clinical symptoms and cannot differentiate between current active disease and past infection.[1 30] The most severe cases are rare.[18] Some people may develop the following:

Ocular toxocarosis (ocular larva migrans)

This occurs when *Toxocara* larvae migrate to the eye.[6] Symptoms and signs include vision loss, eye inflammation or damage to the retina.[6] Typically, only one eye is affected.[6] It is most common among children aged 5–10 years.[28]

Visceral toxocarosis (visceral larva migrans)

This occurs when *Toxocara* larvae migrate to body organs.[6] Symptoms of visceral toxocarosis include fever, fatigue, coughing, wheezing or abdominal pain or cardiac problems including myocarditis, pericarditis and Loeffler's endocarditis.[1 6 31] It is most common in children under 3 years old.[32]

Neurotoxocarosis

This is a central nervous system (CNS) manifestation of *Toxocara* infection; epilepsy, neuropsychological deficits, eosinophilic meningoencephalitis, myelitis and cerebral vasculitis have been described.[26–28] This could be due to neurodegeneration, neuronal damage, granulomatous changes or autoantibodies in the brain.[33]

Covert or common toxocarosis

This describes seropositive people who were asymptomatic or had mild or nonspecific symptoms for example, fever, loss of appetite, headache, nausea, lethargy, abdominal pain, cough, wheeze, itching or rash.[28 34] Systematic reviews have reported an association between *Toxocara* seropositivity and asthma in children (OR 1.91; 95% CI 1.47 to 2.47) and urticaria (OR 2.97; 95% CI 1.53 to 5.76), but not atopy (OR 1.08; 0.55 to 2.15) or eczema (OR 1.62; 0.95 to 2.78).[35 36]

UK prevalence of *Toxocara*

Domestic dogs and cats

Longitudinal studies for shedding in cats and dogs, as eggs are long-lived in the environment and cats and dogs shed intermittently over time, have been suggested as important but lacking in the evidence base; such studies would be expensive to conduct.

In urban areas of Lancashire in the UK, in a study of 171 domestic dogs and 131 domestic cats, at least 6 months old, that had not been treated with anthelmintics since 6 months of age nor in the 3 weeks prior to testing, 5.3% of dogs (9/171) were positive for *T. canis* and 26% of cats (34/131) were infected with *T. cati*.[37]

In a more recent study of fresh faecal samples collected from 2469 dogs visiting 164 parks in 33 cities across 12 countries, Cardiff, Glasgow, Manchester and Reading were sampled in the UK.[38] There were no samples positive for ascarids (the group including *Toxocara* species) among the 304 UK samples.[38] Of

the owners of these dogs in the UK, 64.5% reported that they had treated their dog with anthelminthics within the previous 3 months.[38]

Over all the countries in this study, 3.6% of dogs were positive for ascarids (95% CI 2.9 to 4.4); most of these were in dogs aged under 1 year (6.2% at <1 year vs 3.1% at 1–3 years, 3.9% at 4–6 years and 2.5% at 7 years or older).[38] The proportion of intestinal parasites by owner-reported time of last anthelmintic administration across all countries was 2.2% (95% CI 0.9% to 4.5%) at <1 month, 3.5% (95% CI 2.2% to 5.2%) at 1–3 months, 4.1% (95% CI 2.4% to 6.6%) at 4–6 months, 5.8% (95% CI 3.0% to 9.9%) at 7–12 months and 4.9% (95% CI 2.6% to 8.3%) at >12 months.[38] The risk in dogs under 1 year old (6.2%) was higher than in older dogs (3.1%) or dogs who had been treated within the last 6 months (3.4%), implying that focusing deworming efforts on dogs under 1 year old has a greater potential to reduce soil contamination than increasing the frequency of treating older dogs from 4–6 monthly to 1–3 monthly, or 1–3 monthly to monthly. Conversely, reducing the treatment frequency from monthly to 3-monthly would not increase the risk of soil contamination with *Toxocara* by a large amount (from 2.2% to 3.5%), but would reduce the amount of parasiticides potentially reaching the environment by 67%. Similarly, reducing the treatment frequency from 3-monthly to 6-monthly would not increase the risk of soil contamination with *Toxocara* by a large amount (from 3.5% to 4.1%), but would reduce the amount of parasiticides potentially reaching the environment by 50%.

Soil samples

The amount of soil contamination by *Toxocara* eggs has been suggested as a gap in the evidence due to a lack of funding for longitudinal studies.

In a study of soil contamination of public parks in the East Midlands region of the UK (Nottingham, Derby, and Leicester), 32/405 (7.9%) of soil samples collected tested positive for *Toxocara* spp eggs.[39]

In another study, five soil samples were taken from each of 142 parks and recreational grounds across England, Wales, Scotland, Northern Ireland and the Ireland.[40] Samples were processed sequentially, starting with one sample per park. If the first sample was positive, no further samples were processed and the park was categorised as positive. For parks classified as negative based on the first sample, the second sample was processed and so on for samples three to five. In total, 123 samples were classed as positive, 136 as negative and 451 were not tested. The severity of dog fouling in the parks was both negatively correlated with the level of provision of dog waste disposal facilities and/or deterrents to dog fouling, and positively correlated with detection of eggs in soil samples. This suggests that the provision of signs and waste bins, and actual removal of dog faecal material, is associated with a reduced risk of eggs contaminating the environment.[40]

It is worth noting that some of the studies of prevalence of *Toxocara* infection in animals and contamination of soil samples with *Toxacara* eggs were supported by companies that make pharmaceutical products for animals.

Humans

The true number of cases that occur each year is difficult to estimate as most covert infections go undiagnosed due to less severe systemic manifestations and nonspecific laboratory abnormalities[28]; also some cases reported in the UK may have been acquired abroad.[18] Of note, *Toxocara* infection is not a notifiable disease in the UK[41] or in the USA.[30] The true incidence of human toxocarosis has been suggested as a gap in the evidence.

In a review of toxocarosis reports in the literature in the 46 years between 1972 and 2017, a total of 106 cases were reported from the UK, including 57 cases of ocular toxocarosis, 46 of covert toxocarosis, three of neurotoxocarosis and one of visceral larva migrans.[42]

A study reported data from a routine reporting surveillance system for positive microbiological results obtained in NHS and public laboratories in England and Wales since 1975.[18] It found 672 positive samples recorded for *Toxocara* infections between 1975 and 2009 (an average of around 19 per year), although *Toxocara* results are not considered to be 'diagnostic' in this system. Numbers fell to less than 10 per year in 1996.[18] Between 2000 and 2009, a total of 33 cases were reported (an average of around 3 per year). The same publication also reported cases using the Hospital of Tropical Diseases database (which reports only positive 'diagnostic' results) and found 127 cases with positive laboratory results for *Toxocara* in England and Wales between 2000 and 2009 (an average of around 13 per year).[18]

The disparity between the very small number of reported cases of human infection in the literature (106 cases in 46 years or 2.3 per year) and the higher numbers in the laboratory data suggest that, as for animals, laboratory evidence of infection does not correlate with clinical symptoms.

Preventing or reducing the risk of infection

Suggestions from the literature

Key aspects of prevention and control include:

- Education about toxocarosis and its prevention[43]; avoiding touching material that might be contaminated by animal faeces[6,44]; washing hands[1]; washing raw fruit, vegetables and mushrooms before eating them[16,44]; chilling, freezing and thorough cooking of potentially contaminated foods.[17]
- Faecal clean-up laws and legislation to control stray dogs and feral cat populations (eg, neutering and rehoming)[16,45]; cleaning up faeces and provision of disposal bins and bags[16]; fencing around children's playgrounds to prevent entry of animals[16] and covering sandboxes when not in use.[6,16] Actions focusing solely on household dogs and cats are unlikely to sufficiently reduce environmental contamination with eggs, as stray cats and foxes are also important contributors.[9] In the USA and most European countries, stray cats and dogs are usually removed from the streets by the authorities and are sheltered until adopted or euthanised, and pet owners remove and properly dispose of pet faeces from playgrounds and park soil after defecation, which probably reduce the parasitic load from soil environments and consequent exposure of humans to *Toxocara* spp eggs during outdoor activities.[46] The combination of the Independent on Sunday's 1994 'Dirty Dogs Campaign' and the 1996 Dogs (Fouling of Land) Act immediately preceded a drop in case numbers in the UK, which does not necessarily imply causation, but may have been a contributing factor.[18]
- Deworming for puppies and kittens.[1] Puppies younger than 6 months of age are unlikely to have acquired resistance against patent infections with *Toxocara* spp, and contribute the most to egg production, so current advice should be followed: puppies should be dewormed every 2 weeks up to 2 weeks postweaning, followed by monthly deworming up to the age of 6 months.[9,45] Kittens should also be similarly treated.[9]
- Regular deworming treatments are supported by bodies such as the European Scientific Counsel Companion Animal Parasites, which receives funding from veterinary pharmaceutical companies that market parasiticides (which could be a potential conflict of interest).[5,47] In practice, animals may be treated monthly on a routine basis without risk factors being present or assessment of faecal samples.[10] This may be influenced by the fact that prophylactic treatment for parasites often forms part of veterinary practice health plans for small animals, and may

also be encouraged by the availability of parasiticides over the counter.[5] Routinely deworming cats and dogs monthly is popular in the USA—partly due to the presence of heartworm in many states, but this may be seen as driven by sales rather than being evidence based, requires high compliance and could lead to development of resistance, so some UK authors regard this as unsustainable and prefer a risk-assessment approach.[4,5] Even deworming adult dogs four times a year is not well supported by evidence.[9] It has been questioned whether universal frequent deworming of pet dogs is justified, as over 90% of adult dogs do not shed *Toxocara* eggs and have acquired resistance to the infection, while cats (pet and stray) and foxes also contribute to *Toxocara* contamination of the environment.[9]

- Ideally, adult dogs and cats should be risk-assessed or tested prior to any deworming treatment.[5] The risk analysis should consider factors such as the age of the animal; whether pregnant or lactating; whether the animal hunts and eats potentially contaminated raw meat or lives in kennels/catteries, and whether it has contact with parks/sandpits, young children or people at higher risk (eg, those who are immunocompromised), or on faecal analysis prior to treatment.[16,4,5] Parasitised animals should be treated and, if necessary, monitored by faecal examination (eg, animals with persistent clinical signs or suspected resistance).[16]

For dogs over 6 months old, the relative contributions of various control measures was modelled in the Netherlands.[9] Current rates of owners reporting 'never or rarely' cleaning up dog faeces ranged from 42% for dogs aged 6–12 months in urban areas to 74% for dogs aged over 12 months in rural areas. By increasing the compliance rates of dog owners to cleaning up faeces by 90%, the proportion of the egg output from non-juvenile dogs in the Netherlands was estimated to be reduced from 39% of the total egg output (from non-juvenile dogs, cats and foxes) to 4%. The same high (90%) compliance to the four times a year deworming advice would only reduce dogs' egg shedding contribution from 39% to 28% of the total. Customised advice for dogs frequently shedding eggs or dogs at high risk of shedding might be more efficient in reducing the contribution of non-juvenile household dogs to the environmental contamination than expecting such a high compliance across owners of asymptomatic and mostly uninfected dogs. The authors concluded that the mandatory clean-up of faeces is a higher priority *Toxocara*-control option than deworming.[9]

British veterinary associations

In terms of the impact of parasiticides on the environment, a joint policy statement from the British Veterinary Association (BVA), British Small Animal Veterinary Association (BSAVA) and British Veterinary Zoological Society (BVZS) states that concerns have been raised that some parasiticides are contaminating the environment (eg, via urine and faeces contaminating the soil).[5] As parasiticides are harmful to a wide range of invertebrates, this could be highly detrimental to wildlife and ecosystems, which could impact on public health. This is an example of a One-Health problem and the potential conflict that exists between the needs of animal health, human health and the health of the wider ecosystem. The policy statement opines that as a health-centred profession, and key players in the One Health agenda, vets recognise the interconnections between the health of humans, animals and the environment.[5]

The joint policy statement from the BVA, BSAVA and BVZS advocates that veterinary professionals should always take a risk-based approach to prescribing medicines, including parasiticides.[5] A 5-point plan from the BVA, BSAVA and BVZS published in 2022[48] includes the following recommendations:

- Promoting regular health checks and providing clear information on all practical ways to prevent animals getting parasites, explaining the symptoms of parasites, informing dog owners of the risks associated with dog fouling and reminding them to always pick up faeces and dispose of them responsibly.
- Understanding the potential risks of parasiticides to animals, humans, and the environment and being able to explain these to patients.
- Taking a risk-based approach to prescribing; avoiding a blanket approach; tailoring products and frequency to the animal's needs and level of risk.

Conclusion

Toxocarosis in humans is uncommon, and if infection does occur, it is usually mild. However, serious consequences can occur, particularly ocular and neurological complications. Infection has also been associated with asthma, urticaria and epilepsy. The infection is spread from faeces (from dogs, cats or foxes) containing *Toxocara* eggs that may contaminate soil and foods and are ingested by other animals or humans (eg, young children ingesting contaminated soil). Key methods to control the infection include education about hygiene practices (such as handwashing after touching soil or animals and before eating); cleaning up faeces promptly; reducing contamination of public areas (especially children's playgrounds and sandpits); controlling stray animals; washing and/or thoroughly cooking potentially contaminated food; and regular deworming of pets (especially young, pregnant or lactating dogs and cats). Good hygiene practices and prompt disposal of faeces are uncontroversial. Publicity and changes in laws about dog fouling may have led to a decrease in infections in the UK, although causation is hard to prove. Areas with anti-fouling signs and lower visible faecal contamination have correlated with lower soil contamination with *Toxocara* eggs. It is important to continue to educate pet owners and the public about potential infection and necessary control measures. The rate of infections among pet dogs is low in the UK, and in other countries even among pet dogs that have not received deworming treatments for over 12 months. It is important to bear in mind the potential unwanted effects of deworming control measures, which include contamination of the environment with parasiticides. The 2021 BVA, BSAVA and BVZS joint policy statement now advocates that a benefit/risk assessment of each individual case should determine the choice of deworming treatment and frequency of administration rather than blanket treatment of all animals, most of which are at low risk of suffering from *Toxocara* infection or transmitting illness to humans. Focusing deworming treatments on dogs under a year old is likely to have the greatest impact on reducing transmission of eggs into soil, while reducing the frequency of deworming treatments for older animals (at lower risk) could reduce the impact of parasiticides on the environment while likely having little effect on the very low numbers of cases of human toxocarosis in the UK.

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