Risks of Zoonoses from Dogs On Sporting fields

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Contents

Executive summary

This paper examines the various helminth, protozoan, bacterial and viral organisms which may occur in dog faeces and which may constitute a risk to human health. It also considers the relative risk posed by dogs which are deliberately exercised by their owners on sporting fields as opposed to the risks from stray dogs and foxes defaecating in these areas.

Worms such as the Dog Roundworm *Toxocara canis* and Hydatid Tapeworm *Echinococcus granulosus*, and bacteria such as *Salmonella, Campylobacter* and *Escherichia coli* are potential pathogens for humans, with potentially serious consequences. However, in almost all cases the risk to humans of these organisms is positively associated with proximity to dogs (i.e. owning a dog), poor dog health (especially diarrhoea), and poor human hygiene such as playing in contaminated soil, eating soil, failure to wash hands after dog or soil contact, kissing dogs or allowing licking on the face, and eating during the above activities. Sporting activities on fields co-occupied by dogs is not mentioned in the veterinary or medical literature as a risk factor.

The incidence of zoonotic organisms in faeces from Canberra dogs is not known, but may be inferred to be low for various reasons including climate and the socio-economic and educational status of dog owners. The risk to those whose immune systems are impaired is significantly higher than to healthy people, who are more likely to be using the sporting fields for activities where they will be in contact with faeces or contaminated soil. Children are probably most at risk at ages where they “play in the dirt” in sand pits and the like, rather than once they start to play sport, but clearly some children of susceptible age will use sporting fields and other public parks

In the author’s opinion, risks to human health can be more effectively and more practically reduced by educating the public about the need to maintain good dog health, including the need for regular effective worming of pets, and by encouraging compliance with existing laws requiring the removal of faeces from public places. This should include provision of bins for the disposal of dog faeces and design of public open space to encourage dog owners to exercise and toilet their pets away from sporting fields and other areas of high human use.

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The author is a veterinarian in small animal practice since 1982, including 17 years in Canberra and 1 year in Gundaroo.

Introduction

This review of the health risks to humans of dogs on sporting fields was originally prepared at the request of Mr Ian Baird, Program Manager, Policy and Planning, Canberra Urban Parks and Places, on behalf of the Australian Veterinary Association. It was provided to assist the ACT Government during a review of the *Companion Animals Act 2000 (CAA200),* particularly with respect to dog access to public places.

Although the review refers to the ACT, the facts and principles presented are applicable to all temperate parts of Australia. Local incidence of parasites in dogs and serological incidence of zoonotic disease in people should be sought for the local area.

It is based upon a review of the scientific literature, but does not formally assess risk, because it is not being conducted by a specialist epidemiologist or risk manager. However, the author is a veterinarian with more than twenty five years experience, and a particular interest in parasitology. Veterinarians are trained in, and accept responsibility to safeguard against, zoonoses – that is, diseases which can be spread between animals and man.

This review does not consider physical risks associated with the presence of dogs on sporting fields, such as dog harassment, attack or bite on humans, nor the risk of tripping or falling over a dog. These risks are already prevented in the sense that they are legislated against. *CAA2000* forbids anyone to take a dog onto a sporting ground when sport or training is in progress, or to allow a dog to be in a public place unaccompanied and/or unrestrained:

42 Prohibited places

(3) A person must not take a dog onto a field or playing area where sport is being played or training for sport is being conducted.

44 Dogs in public places to be restrained

(1) A carer must not be in a public place with a dog that is not restrained by a leash, unless the person is in an area designated as an area where dogs are not required to be restrained by a leash.

Maximum penalty: 5 penalty units.

(2) A keeper must not be in a public place with a dog that is not restrained by a leash, unless the person is in an area designated as an area where dogs are not required to be restrained by a leash.

Maximum penalty: 5 penalty units.

(3) The keeper of a dog commits an offence if the dog—

(a) is in a public place; and

(b) is not with a carer.

This review considers the risks to human health associated with dog faeces and urine being deposited on sporting fields. In passing it comments on risks associated with dog excreta in other public places, and considers the risk from other animals, particularly wild canids. Three groups of organisms are considered to pose a risk: Helminths (worms), Protozoa, and Bacteria.

Helminths

Several helminth parasites of dogs may be transmitted to humans, namely the dog roundworm *Toxocara canis*, hookworms (*Ancylostoma caninum, Uncinaria stenocephala)*, and hydatid tapeworm *Echinococcus granulosus*. The following parasites are also considered to be zoonotic, but will not be further considered here:

- dog whipworm *Trichuris canis* [123] (unknown in humans in Australia)
- heartworm *Dirofilaria immitis* (uncommon in dogs in ACT, spread indirectly via mosquitoes rather than directly or via faeces)
- flea tapeworm *Dipylidium caninum* (infection of humans occurs only via swallowing the intermediate host, a flea)

Dogs can also act as transport hosts for the human roundworm *Ascaris lumbricoides*, whipworm *Trichuris trichiura*, and Coccidia (a protozoa) *Isospora belli* but to do so must ingest infected human faeces.[4]

Toxocara canis

The dog roundworm *Toxocara canis* is a common parasite of dogs throughout the world, particularly in young dogs. Puppies acquire infection pre-natally through the placenta, post-natally via the mammary glands, and from the environment (embryonated eggs, and larvae in paratenic (transport) hosts (rodents and birds)). A large proportion of larvae acquired do not complete their development to adult worms in the intestine, but rather remain as larval (infective) stages in the dog's tissues, awaiting their opportunity to transfer to puppies. The male dog is largely a "dead end" host, since it cannot transmit larvae to its offspring via the placenta or mammary glands. Perhaps for this reason, adult male dogs carry heavier burdens of worms in their intestine and are a more important source of eggs contaminating the environment than adult females[5].

Adult *T. canis* have a life span of about 4 months and females can produce 200,000 eggs / day[6]. However, infection rates are much lower in adult dogs than in puppies, and hence faecal shedding of eggs is much greater in pups than in adults. Puppies can shed 15,000 eggs per gram of faeces per day[7].

Human infection causes a syndrome called **larva migrans. Visceral larva migrans** (VLM) refers to the migration and sequestration of larvae of *T canis* (and other worms including the cat roundworm *T. cati*) in the internal organs (viscera) of humans – the most common site is the liver. Migration may also occur (with potentially serous consequences) to the brain, and eye (**ocular larva migrans** (OLM)) where it can cause blindness or cause tissue changes similar to a retinal tumour resulting in eye removal. VLM has a mean age at diagnosis of 1-4 years, while for OLM it is 7-8 years[6].

Human infection occurs by ingestion of embyonated eggs, containing the second stage (L2) larva. Embryonation occurs outside the host, from 10-15 days[8], two weeks[6], or 28 days[9] - unembryonated eggs (i.e. those in fresh faeces) are not infective, and will pass through a human (or any other animal) without causing infection. All surveys show that infection rates are much higher in children, and are associated with pica or geophagia (soil eating), failing to wash hands before eating, and dog ownership (probably especially puppies). A rural background may increase risk, and socio-economic conditions are also important.

Under optimal conditions of moisture, oxygenation and temperature, eggs survive for many months or years, providing a reservoir of infection. The eggs are sticky and adhere to, and may be acquired from, the hair, mouth and environment of dogs, especially puppies. Chemicals (including Calcium cyanamide[10], Lysol, formalin, hydrochloric acid and sodium hydroxide Dunsmore and Shaw 2000) are ineffective at killing the eggs. They are susceptible to heat (40 ^{o}C) and dessication. Heat (flame throwers) and Sodium hypochlorite 1% (followed by vigorous cleaning) can be used in concrete dog runs etc, or topsoil can be turned over so that the eggs are buried[6]. Prevention is accomplished by

1) maintaining dogs free of worms by regular administration of anthelminthics
2) removal of dog faeces from the environment before the eggs are able to embryonate (i.e. within 2 weeks), including burying [11]
3) good personal hygiene.

It should be noted that worming with common human antheminthics (Pyrantel, Mebendazole) are not effective against the larval stages of *T. canis*, and will not prevent development of disease.

The eggs will not embryonate at < 12 ^{o}C, although they will survive at – 25 ^{o}C. They die at 37 ^{o}C before embryonating. Adequate oxygen, and a relative humidity of 58-95%, are required for development[12]. Since only embyonated eggs are infective, fresh faeces (less than two weeks old), ground temperatures less than 12 or more than 37, or low humidty in the eggs micro-environment, all render faeces risk free for *T. canis*.

Eggs may be infective, but do not constitute a risk, if they are washed into soil[5]. In soil, they will not be ingested by people unless the soil is deliberately (or inadvertently) eaten. For this reason, children's playgrounds, sand pits etc constitute a much higher risk, and it is appropriate that dogs be excluded from these areas, preferably by fencing.

<u>Prevalence</u>

The prevalence of *T. canis* eggs in dog faeces and / or soil is commonly reported overseas (see table 1), and some data is available for Australia. Ng and Kelly found *T. canis* in 35.1% of stray dogs in Sydney in 1975; the prevalence was 63.8% were dogs less than 6 months of age[13]. A survey of 703 pound dogs in North-East Victoria revealed 37% infected with *T. canis* in 1982[14]. In 1993, *T. canis* was found in 2.3-17.4% of faecal samples collected from parks, owned and stray dogs in Melbourne and Geelong [15]. In Hobart, 10.9% of faecal specimens from urban dogs and 7.7% of park and beach specimens were positive for *T. canis* eggs, and 18% of samples from human blood donors were positive for Toxocara antibody (1995)[16]. More recently, only one sample of 180 soil samples from 9 locations in suburban Melbourne contained *T. canis* eggs in 2003, and the authors concluded that "the acquisition of the disease is unlikely to be from public parks"[17]. The presence of *T. canis* eggs in soil is significant, but the likelihood of these eggs becoming or remaining infectious due to the effects of heat, cold, low humidity or time needs to be considered.

Two factors are probably responsible for the apparent decline in worm eggs recovered from soil and faeces in Australia – increasing compliance with appropriate worming recommendations, and reduced wandering of dogs in response to more restrictive “leash laws” and more responsible pet ownership. The incidence of worms is generally higher in stray than in owned dogs, and these dogs probably constitute a greater risk of zoonoses to the general public.

Surveys of Australians and New Zealanders from 1985-1987 reveal antibodies indicating exposure to *T. canis* in 3-10% of the population. Humans with higher than usual exposure (NZ Hydatid control officers and Australian Aborigines) have 25 and 32% evidence of infection. However, very few of these are actually affected by the parasite, which is quickly brought under control[5].

Table 1 – Prevalence of *Toxocara canis* in dog faeces, soil samples, and human sera outside Australia

Dog Faeces	Soil	Humans	Location	Reference
	66%		Parks, London	18
34%	77%		Montreal	19
30%	40%		Philadelphia	20
76%	19%		Philadelphia	18
33.6%	50%	1.6%	Marche, Italy	21
		2%	Eliazig, Turkey	22
		36.5-44.2%	Lubin, Poland	23
66.7% (pups)		7.3% (children)	Bogota	24
		25.4%	Cordoba, Argentina	25
17.2%		20.4%	Salta Province, Argentina	26
	18,8%	2.9%	Attiki, Greece	27
	80%	7.33%	Lima, Peru	28
		5.3%	Valdivia, Chile	29
		33% (of vets)	Vienna, Austria	30
		63.2% children	Bali, Indonesia	31
	37.3%		Stara Zagora, Bulgaria	32
8%			Jamaica	33
6.6%			Houston, Texas	34
11.1%			Pisa, Italy	35
13.5%			Santiago, Chile	36
		7.9%	Poznan, Poland	37
0-4.3%	0-8.3%		Austrian towns	38
1.6%			Blackburn, UK	39
3.6% (owned) 25%(stray).			Cork, Ireland	40
	6.59%		Vet school, Madras, India	41

Epidemiological notes:

- Soil contamination increased after a dog show was held in a park [10].
- Much higher contamination outside than inside a fenced play area [18]
- Egg viability dropped off from 77.7% to 54.4% over Winter (Montreal), 7 of 3339 samples of sand from playgrounds contained eggs[19]
- Nearly 50% of rural vs. 25% urban dogs infected (Marche, Italy)[21]
- Antibodies were found more commonly in men than in women. Nearly 50% of cases were < 15 years of age; and 56% had a rural background. 52% lived in a house compared to 18% living in a flat[23]
- higher prevalence in children under 5 years. The only risk factor was not washing hands before eating. However, several other factors such as age, gender, geophagy and the increase in the density of dogs favoured transmission[24]
- an area of high risk; more children infected in the age group 0-4 years old. Sex and dog coexistence did not influence the results[25]
- of 90 children hospitalised for VLM in the Slovak Republic, the highest admission rate was in the age groups of 3-5 years (43.3%) and 6-10 years (36.7%). The most conspicuous changes occurred in the age group of 1-5 years. A high percentage of those seropositive belonged to dog-keeping and puppy-breeding families.[42]
- Of 1023 16-83 year olds in Lima, Peru**,** seroprevalence was slightly higher in females (8.48%) and in individuals aged >45 years (10.82%)[28]
- In Poznan, Poland, the incidence of antibodies to *T. canis* was 3 times the general population. Geophagia and dog ownership were the major associated risk factors. Neither present nor past symptoms and signs of toxocariasis were found in any of the seropositive children[37]

The incidence of *Toxocara canis* in dogs in the ACT is unknown, although it is likely to be similar to reported figures from Melbourne, given our similar socio-economic and educational status . Dr David Jenkins from the Australian Hydatid Control and Epidemiology Program, found about 10% of dogs producing any helminth eggs in their faeces in a survey at the ACT Dog Pound in the late 1990s. (*pers. Comm*).

Conclusion

The major risk factors for the development of *Toxocara* larva migrans in man are eating dirt, poor socio-economic status, ownership/prolonged contact with dogs, and perhaps rural lifestyle. Stray dogs are more likely to contaminate sporting fields than are owned dogs being deliberately exercised there, because they are likely to be carrying higher worm burdens due to infrequent antheminthic application. The brief contact with soil in sporting fields, or indeed with dog faeces, is unlikely to constitute a significant risk for *Toxocara* larva migrans. However, as for all the other pathogens discussed below, dog (and other animal) faeces should be excluded from children's playgrounds and sandpits by appropriate fencing.

Uncinaria stenocephala

Hookworms are common parasites of dogs (and other species including man) throughout the world, but individual species tend to occur in specific geographical locations. The most common hookworm of dogs in Australia[7 5] and also throughout the world[43], *Ancylostoma caninum*, is a parasite of warm areas, being limited to north of 35 °S[44]. The canine hookworm most commonly implicated as the cause of the zoonotic disease **cutaneous larva migrans** (CLM) (creeping eruption) in Australia is *A. braziliense* [44], [5], which is limited to far northern Australia, but *A. caninum* and *Uncinaria stenocephala* can also cause this disease. *U. stenocephala* is a cool weather parasite, being limited to below 30 °S. Canberra lies just north of 35 °S, supposedly within the range for *A. caninum*, though this parasite has rarely if ever been recorded here. *U. stenocephala* is essentially the only hookworm recorded in dogs, cats, dingoes or foxes in the ACT.

Hookworms have a direct lifecycle, with eggs passed in faeces onto the ground, hatching into larvae which go through a succession of moults until they become infective (L3 stage). For *U. stenocephala*, the optimal temperature for development is 20 °C, with eggs hatching after 12 hours and L3 in 4 days. Development is delayed at lower temperatures (for example, L3 at 28 days at 7.5 °C), and no larvae become infective at 37 °C. 10% of eggs survive for only 2 days at –10 °C. Larvae do not develop in the centre of faeces, but eggs will hatch if the faeces are disturbed and break up into soil. Infective larvae crawl out of faecal material and onto vegetation. ([12]). All, but especially early, larval stages are susceptible to desiccation and heat[45].

Infection of dogs occurs via the mouth or by skin penetration, and the latter is the likely route in humans (except perhaps in small children). Humans with CLM typically are either:

- Young children and adults who go barefoot in areas frequented by dogs, and children in contaminated playgrounds and sandpits
- Travellers, particularly from tropical locations, especially those who have spent time on beaches where dogs defaecate
- Tradesmen who work under houses, crawling over dirt contaminated with dog faeces, and nursery workers[45]

98 (0.7%) patients of 13,300 attending a travel related disease clinic of the University of Munich (Germany) had CLM. None of these had visited Australia, despite Australia being a common destination for Europeans, and despite records of CLM in Australia. Only visitors to tropical countries were affected, apparently with *A. braziliense* or, less commonly, with *A. caninum*[46].

CLM is rare enough to be reported in medical journals when small numbers of cases are seen[474849], the latter two cases specifying the involvement of *Ancylostoma* species.

Prevalence

Uncinaria was found in 10% of Sydney dogs in 1975[13], 26.9% of pound dogs in a survey in North Eastern Victoria (1982) [14], hookworm eggs were recovered from 1.8% of dogs and 0.7% public places in Hobart in 1995[16], and it has been suggested that the incidence of hookworms declines with increasing latitude[5]. The incidence of CLM in Australia is not available from the medical research data base "Medline".

Conclusion

Uncinaria is an unusual parasite of dogs in Canberra (personal experience), and is an uncommon cause of CLM worldwide. CLM occurs when there is relatively prolonged contact between bare skin and contaminated soil or vegetation. The risk of CLM from dog faeces on sporting fields is negligible to non-existent.

Echinococcus granulosus

Echinococcus granulosus, the Hydatid Tapeworm, is a tiny parasite of the small intestines of dogs, dingoes[7 44], foxes [5051], and also wolves, jackals, coyotes, and African Lions[52], causing no disease and no symptoms, even in massive numbers. Each worm produces about 1,000 eggs every two weeks[5], and dogs can carry up to 300,000 worms, although domestic dogs do not usually carry such large numbers. Dingoes, on the other hand, and wild dogs infected with the "sylvatic strain" of *Echinococcus*, commonly carry heavy burdens[53]. Passage of large numbers of eggs in the faeces of dogs, especially mobile dogs, results in widespread contamination of pasture, bushland etc. Eggs are spread over wide areas by wind, insects, birds and the like, and a single dog could infect up to 30,000 hectares[5]. Eggs are susceptible to desiccation, but are very cold tolerant, and may survive in the field for at least a year. They are immediately infective.

Eggs are ingested by intermediate hosts, usually by grazing, but also accidentally by contact with dog faeces, soil, and eggs which have transferred onto the dog's coat and mouth by rolling in or ingesting faeces, licking etc. Oncospheres (an intermediate stage) hatch from eggs in the intestine, penetrate the intestinal wall, and disperse throughout the body, but predominantly the liver and lungs. Here they form cysts which grow slowly and contain many thousands of protoscolices, which are infective for dogs if swallowed. It is these cysts which cause disease in humans, growing slowly over many years with few signs in some, causing pain or severe reactions in others, or causing serious disease if they form in the brain or other vital organ. Most humans require surgical treatment, although medication (albendazole) may also be used.

It has long been believed that there are two strains of *E. granulosus* in Australia which display morphological and antigenic differences. The "domestic strain" has a dog – sheep (or cattle) – dog cycle, while the "sylvatic (wildlife) strain" has a dingo – macropod – dingo cycle, although there is some overlap. The domestic strain has been recovered from dingoes, and is believed responsible for transmission to cattle in Queensland[54], wild dogs[53 55], and foxes[51 56]. Human hydatidosis in Australia is almost invariably caused by the domestic strain, although there has been one report of human infection with the sylvatic strain. However, it is now considered that there is only one strain (the "sheep" strain) that is opportunistic, i.e. infecting whatever hosts are available - wildlife or domestic and occasionally human (D Jenkins, Australian Hydatid Control and Epidemiology Program, Canberra, *pers. comm.* April 2004).

Prevalence

The highest prevalence of infection in dogs in Australia occurs in south east NSW, with rural dogs recording 3.5-32.3% infection rates. Rates in Victoria (3%)[although none were found in pound dogs in north eastern Victoria in 1982 [16]], and Western Australia (0.7%), are lower, and the parasite has been eliminated in Tasmania and New Zealand. The parasite has also been recorded in dogs in Sydney[5]. 11.4% of farms in the ACT had dogs infected with *E. granulosus* in 1977[57].

Wild dogs and dingoes often have very high infection rates – 90% (SE Queensland[54], 61% SE NSW[58], 87%[53], and although the sylvatic strain predominates, the domestic strain is also seen. Of significance is the 7% infection rate found in foxes killed on roads in Canberra[56]. Foxes can harbour the domestic strain of hydatids, probably in similar burdens to the sylvatic strain[50], and a fox infected with the domestic strain was recovered near Gundaroo, just north of Canberra.

Infection rates in SE NSW have been reported at 5.4% in mature sheep, with some properties in the Cooma district having up to 42%[59]. The high prevalence in wild dogs around Canberra suggests the presence of hydatids in macropods in the area, but a survey of road kill in Canberra failed to recover any hydatid cysts[56], implying that these urban foxes may have been infected from eating sheep and lambs.

Canberra lies in the area of greatest risk (on mainland Australia) for human hydatid disease, with a peak incidence of 26.2 cases / 100,000 in the period 1968-1973[5]. Jenkins and Power report 195 new cases of hydatid disease in humans in NSW and the ACT between 1987-1992. Most of the patients lived in the eastern half of the State, including the ACT. It is of note that 60% of the patients living in major cities were born overseas[60].

Most humans who contract Hydatid disease have a rural connection – commonly infection occurs when they are children but is not detected for years or decades. Many people in the ACT live on or visit farms nearby, where sheep are commonly raised. It is of concern that Canberran dogs also visit farms, or are exercised in the rural and bush-land in and around Canberra, often off lead and under-supervised. Such dogs who consume infected material from carcasses of sheep, pigs, kangaroos and wallabies which are less than three days dead (D Jenkins *pers. comm.*) may contract *E. granulosus*, and be excreting eggs in their faeces after about 6 weeks. These eggs constitute a risk to the humans, especially children, of the dog's family, friends and neighbours, but also to strangers if the dog is exercised in public areas.

Fortunately, local veterinarians are very conscious of the risks, and are pro-active in educating their clients and ensuring that appropriate care is in place. Four rules for hydatid prevention are taught:

1. Don't feed dogs raw meat or offal – use commercial foods
2. Don't allow dogs to wander or be unsupervised where they might eat from a carcass
3. Practice (and teach) good personal hygiene – don't kiss dogs, don't let them lick you on the face, wash hands after touching dogs, don't eat while playing with dogs
4. Worm at risk dogs with Praziquantel at least every 6 weeks.

Most dog owners heed these warnings carefully, aware of the serious risk to their own and loved ones health.

There are others in the community who may be less exposed to this message and whose dogs may constitute a greater risk – those who use their dogs for hunting, or who bring the products of hunting back to feed dogs. This relatively small group of dogs is seen, in my experience, less frequently by veterinarians, and often has a lower standard of general health care. However, these dogs appear to be rarely if ever exercised outside their owner's properties except when hunting, so the risk to the general community is probably low.

Hydatid disease is uncommon in humans who live in towns and cities, risk of infection increasing with duration of exposure to infected dogs and to contaminated country. The risk of human infection from sporting fields is negligible given:

Relatively brief contact with the sporting field

Relatively low risk of dogs being exercised on sporting fields being exposed to a source of infection

High compliance with worming recommendations in most Canberra dogs (personal experience)

<u>Conclusion</u>

Canberrans are at risk for Hydatid disease from:

Eggs from faeces dispersed into the environment through various natural processes not associated with direct presence of faeces,

Infected faeces from animals other than domestic dogs (foxes and perhaps wild dogs/dingoes) moving through suburban areas and over sporting fields.

Banning owned dogs from sporting fields will not reduce these risks.

Protozoa

Giardia

Giardia are protozoan parasites of the intestinal tract of many animal species, including man. Their presence is often sub-clinical, even in large numbers, although acute or chronic diarrhoea, sometimes with abdominal pain, may occur. In the past, *Giardia* from individual animal species were named for those species[8], and it was thought that animal species of *Giardia* could not be spread to humans[44]. Partly because the morphology of Giardia from all host species is identical, their taxonomy has changed. There has also been much debate about their zoonotic potential.

The potential of Giardia as a zoonosis has been questioned since at least 1979[61], and was raised in Australia as early as 1986[62]. Several Japanese studies have examined the likelihood of Giardia being zoonotic[636465] - none of the owners of 307 infected dogs (out of 2652 tested – 11.5%) were infected, and the authors concluded that the risk for dog to human infection was very low. Gasser (1990) reported that techniques to determine whether Giardia could be spread from animals to man were available, and that direct transmission studies were necessary[66]. A review in 2000 commented that "the contribution of zoonotic transmission remains unclear"[67]. Human infection with Giardia mostly occurs via infected water or food contaminated with infected water; and presumably human sewage is the main source of such contamination. However, a recent survey of pristine water catchments (10 rivers in 7 National Parks) in eastern Australia found all to be infected with *Giardia* (and *Cryptosporidium*)[68].

<u>Prevalence</u>

Giardia has been reported in 21% of 333 dogs in Perth[62], and in 14.5% of dogs and 1.4% of park soil samples in Hobart[16]. *Giardia* also occur in the faeces of cats, and were reported in 14% of cats in the Perth study. A higher infection rate was recorded from refuge and breeding kennel dogs than from pets, due to higher living densities, environmental contamination rates, and perhaps lower general health and planes of nutrition.

Giardia infection in dogs appears to be common overseas, with prevalence reported at 11.5% in Japan (62-64), 14.5% in London (29.4% in dogs 6-12 months of age)[69], 40% in Dublin, Ireland[70], and 35.9% in puppies in the US[71]

<u>Conclusion</u>
Despite the probable high incidence in dogs in the ACT, Giardia is a most unlikely risk for man from dog faeces. The parasite is mostly water born due to human faecal contamination, and even close proximity to dogs has not resulted in significant human infection.

Cryptosporidium

Cryptosporidium parvum is a tiny (4-5µm) coccidian, which is a primary pathogen causing diarrhoea in animals and man[72]. The organism survives for long periods in the environment, readily contaminates water from faeces, and is extremely difficult to kill with chemicals. Other species occur in animals and birds. *C. parvum* of bovine, but not human, origin can infect dogs[73], a human and his dog were found to have different genotypes (cattle and dog, respectively) in Japan[74], and in Osaka, all genetic isolates from dog faeces were of *Cryptosporidium canis* (previously known as the dog genotype), which is thought to be non-pathogenic in humans"[75].

However, the dog strain has been recovered from 1 of 1680 patients with Cryptosporidiosis in England[76], and from an HIV infected human in America[77]. Infection in immunocompetent people is regarded as moderate and self-limiting, which contrasts sharply with the prolonged severe diarrhoea in immunocompromised patients[7879]. Children, dairy farm workers, and travellers are also at risk, as are possibly the owners of infected dogs[80]. Transmission occurs by contaminated drinking and swimming water, food, and directly (faecal-oral), and livestock are commonly incriminated as the source of infection.

Cryptosporidium occurs in dogs worldwide(Edinburgh[81], California 2%[82], Ireland[70], Spain 7.4%[83], Colorado (3.8%)[84]), and in poor communities dogs are regarded as a possible source of infection (Guatemala[85], Brazil[86], Egypt[87]). However, Cryptosporidium had not been identified in dogs in Australia[5], until 2000[88], and the prevalence in Australia is unknown, but likely to be very low.

<u>Conclusion</u>
Cryptosporidium from dogs is regarded as an extremely low risk zoonosis in Canberra.

Other Protozoa

Other potentially zoonotic protozoa recorded in Australian dogs include *Entamoeba histolytica*, but humans are regarded as the source of infection for dogs, rather then the reverse, and *Toxoplasma gondii*. *Toxoplasma* is an important, if clinically unusual, zoonotic parasite of cats. Humans may also be infected from raw or undercooked meat. Dogs have recently been identified as possible mechanical hosts of *T. gondii* if they ingest infected cat faeces – the sporulated oocysts may pass through into the dog's faeces[89]. Unsporulated oocysts in cat faeces applied to dog fur, however, failed to sporulate. Given that cats only excrete *Toxoplasma* oocysts for about 2 weeks, the risk of infection from the faeces of dogs consuming cat faeces is negligible. Only naïve pregnant women (no previous immunity to *Toxoplasma*) and the immuno-incompetent are at risk for clinical disease[90], and about half the Australian population have antibodies to this organism.

Bacteria

Bacteria are ubiquitous in the faeces of all animals, and contact between broken skin and faeces may lead to infection. Of course, soil borne organisms not associated with dog faeces pose exactly the same risk. Several bacteria found in the faeces of dogs are specifically regarded as zoonotic, including *Campylobacter, Salmonella, Escherichia coli* and other faecal coliforms.

Campylobacter

Campylobacter are comma or gull wing shaped gram negative bacteria which may cause diarrhoea or abortion in man and animals. Human cholera is caused by a specific *Campylobacter*[91]. Different species occur in different hosts and cause different patterns of disease. *Campylobacter* is a worldwide zoonosis, and the leading cause of acute bacterial gastro-enteritis in England[92]. *Campylobacter jejuni* and *C. upsaliensis* may cause diarrhoea with blood and mucus in dogs, especially young dogs, and in people, especially children. Infection occurs by ingestion of contaminated food, water, raw milk, or the faeces of infected animals (especially young animals with diarrhoea).

Prevalence of *Campylobacter* varies from 0-49%; 13 of 30 normal and diarrhoeic dogs in Rome were shown to carry *Campylobacter*[93], while 56% of healthy family dogs in Sweden carry the organism[94]. Clinically, it is a rare diagnosis in dogs in the ACT (personal experience).

Dog faeces in public areas do constitute a risk for *Campylobacter* gastro-enteritis, but the risk is higher in children exposed to faeces in play areas or by prolonged contact with dogs (e.g. ownership). The risk to human health of *Campylobacter* in dog faeces on sporting fields is considered to be low.

Salmonella

Salmonellae are gram-negative bacteria, commonly associated with food poisoning in people. The source of the organism is commonly human to human – there is a well understood carrier state which results in outbreaks when present in food handlers. Animals also carry (and may be affected by) all *Salmonella* strains except those causing Typhoid fever and related (paratyphoid) enteric fevers. Zoonotic infection is most commonly due to contamination of food, or the presence of the organism in food such as milk, chicken and eggs. Birds are commonly infected and shed the organism in faeces. The organism survives well in the environment and in water contaminated with organic material. It is unlikely, on the other hand, that it survives more than three weeks in water free of organic waste. *Salmonellae* are susceptible to heating and drying.

Pets, including dogs, cats and reptiles, are also a possible source of infection. Reptiles are a well recognised threat and the sale of some species are controlled in some countries because of *Salmonella*. In mammals, neonates, old animals, animals with concurrent infections, those undergoing the stress of transport, exercise[95], malnutrition, feed changes, pregnancy or surgery are more susceptible to infection and clinical disease. Human neonates and the elderly are most at risk, and risk is increased if taking antibiotics, suffering chronic or debilitating disease including neoplasia, or immunodeficient. Recovered animals may shed the organism (intermittently) for up to 3 months, but a carrier state is not reported in animals as it is for humans, except for highly host adapted strains such as *S. dublin* in cattle and *S. pullorum* in chickens.[96]

Dogs may acquire the organism from the environment, but raw or undercooked meat and eggs are a much more likely source, and all meat for pets should be cooked as if for human consumption. Milk consumed by pets should be pasteurised. Flies are an important source of contamination for Salmonellae as for other bacteria[97]

<u>Prevalence</u>

Table 2 – Prevalence*Salmonella* recovered from dog faeces

In Dog faeces	In the environment	Location	Reference
16%		Bari, Italy	98
	10.3%	Stuttgart, Germany	99
5-6%		Santiago, Chile	100
7.6%		Rome, Italy	101
7.4%		Germany	102
8%		Zurich	103
8%		Rome, Italy	104

Salmonellae are commonly found in dog faeces and may constitute a risk for humans contacting their faeces, or material contaminated with the faeces of an infected dog. The faeces of birds, including ducks, also commonly contain *Salmonellae*, and duck faeces are common contaminants of sporting fields in Canberra. Most human cases are associated with poor food hygiene, and the risk due to dog faeces on sporting fields is considered to be low.

Escherichia coli

E. coli (and other faecal coliforms) are ubiquitous in all animal faeces. *E. coli* shedding the "Shiga" toxin has recently been recovered from the faces of greyhounds with (40%) and without (25%) diarrhoea. Along with other strains of *E. coli*, this organism poses a zoonotic risk. The Shiga toxin causes paralysis, diarrhoea and death when injected into rabbits, mice and guinea pigs, and in people, abdominal cramps, diarrhoea (with mucus and blood) and fever.

E. coli most commonly is recognised as a cause of disease outside the digestive tract, such as urinary tract infections and sepsis, but some strains are associated with acute diarrhoea such as "traveller's diarrhoea" and food poisoning. Serious problems are most likely in the young or immuno-compromised[91]. Recent studies have established that dogs may act as reservoirs of pathogenic *E. coli* affecting the urinary tract and meninges[105 106].

Environmental health authorities are concerned about bacterial contamination of waterways with animal faeces, including dogs, and large volumes of dog faeces are washed into storm water drains after heavy rain. The source of such bacterial contamination can be determined[107 108] by genetic comparison.

E.coli from dog faeces is a possible risk for humans, although the organism is a common contaminant of water and food and these are more likely sources.

Leptospira

Leptospirosis is relatively common in livestock and feral pigs in Australia, and may occur in dogs and horses also. The organism attacks the kidneys and/or liver, and Leptospirosis in man is almost always a zoonosis contracted from animals, mainly through contact with infected urine. Humans have been infected from dogs in England[109], Germany[110], and dogs (along with other animals) have high levels of infection in areas with high human incidence such as Mexico[111], Greece[112], India [113], and Brazil[114]. Clinically normal dogs may shed the organism in their urine, constituting a threat to human health[115].

However, the incidence of Leptospirosis in dogs in the NSW is low[116], and in the ACT and region is very low (personal experience). Dickeson and Love concluded that dogs (and cats and horses) were unlikely to pose a risk to humans in south-eastern Australia. Most human infections are associated with rat urine, for example in cane fields in northern NSW and Queensland.

The risk of Leptospirosis from dog urine on sporting fields is considered to be negligible.

Other Bacteria

Anaerobiospirillum spp. have been show to cause bacteraemia and diarrhoea in people. A study failed to grow the organism in human faeces but it was found in dog and cat faeces[117], establishing pets as the likely source of human infection. No doubt many other bacteria from dog faeces are occasional sources of human infection, but like all diseases discussed, individual risk is highest in children and the immuno-compromised, especially where there is prolonged contact with dogs (i.e. ownership) and poor standards of hygiene (personal, and removal of dog excreta). Dog faeces on sporting fields are a low risk to humans.

Viruses

Rotavirus was found in 2 (3.5%), coronavirus in 7 (12.5%), parvovirus in 13 (23.2%) and both coronavirus and parvovirus in another 5 (8.9%) random dog faecal samples from Paris streets, but the infectivity of these dog strains for humans is not discussed[118]. In another study in Zurich, no enteric viruses were found[103].

Viruses are an unlikely risk for humans from dog faeces.

Foxes

Foxes are commonly seen in Canberra after dusk. Some clearly reside outside the city and visit to scavenge for food scraps, others (particularly those seen close to the city centre and in large institutions such as the Australian National University) almost certainly reside here.

Numerous studies both in Australia and overseas have demonstrated that foxes carry many of the same faecal organisms as dogs such as the helminths *Toxocara canis, Uncinaria stenocephala, Trichuris vulpis,* and antibodies to *Toxoplasma gondii*, amongst other organisms, in Yugoslavia[119], Spain[120], Ireland[121], England[122] and Australia[56 51]. Any consideration of risks of faeces on sporting fields must consider the possibility of contamination with fox faeces. Foxes, unlike dogs, never receive anthelminthic (worming) drugs and are not observed or treated for ill health such as bacterial diarrhoea.

Possible solutions

While this review was not intended to address solutions to the problem of dog faces on sporting fields and the attendant risks, two obvious solutions exist which will be briefly discussed.

Dung beetles

Dung beetles have been used for the disposal of dog faeces since at least 1995, when they were introduced in Warringah Shire in Sydney[123]. They have been introduced into the dog exercise courtyards of housing complexes in Melbourne to assist with faecal control. Dung beetles are attracted to faeces, and create a nest under the mound into which they transport the dung. The optimal species for dogs in this area, *Ontophagus taurus*, will remove 90% of the faecal material within 24 hours. A recent conference in America reported a 99.7% reduction in *Cryptosporidium* in the environment as a consequence of the actions of dung beetles on cattle faeces. Some helminth eggs and larvae, such as *Toxocara*, will be rendered unavailable by burying, while other more mobile species such as *Uncinaria* may still migrate on to vegetation. Clearly, dung beetles have great capacity to reduce the aesthetic and health problems of dog faeces.

However, there are limitations which need to be considered. The named specie is a summer active dung beetle, from November to April in this region. It hibernates over Winter. However, there are winter active species available, although they are larger and fly around at dusk. Dung beetles do not remove all of the faecal pat; they remove 90% of the interior but leave a shell which may look unchanged. Dung beetles are less active in sheltered areas such as under the canopy of trees, where dogs may go to defaecate, but would be active in the middle of sporting fields. Their health is affected by the protein content of the diet of the animal producing the dung, preferring higher protein diets. There has been concern about the effect of some anthelminthics passed in the faeces on dung, but most dogs are wormed intermittently (unlike livestock where prolonged activity formulations are often used), meaning that relatively few faecal pats would affect the beetles, if at all. The one long acting preparation used in dogs contains Moxidectin, which has been shown to be safe for dung beetles.

The above information was obtained from Dr John Sheehan[1], a retired CSIRO scientists who has been researching and supplying dung beetles since 1965, and is happy to present his material.

Faecal disposal

The health problems associated with dog faeces, limited as they may be, can be largely eliminated by owners removing dog faeces from areas where people exercise or recreate. Various strategies are available to encourage this, including enforcing the carriage of faeces removal equipment, and fines for failure to remove faeces

> **46 Removal of faeces**
>
> **(1)** The carer of a dog must hygienically dispose of any faeces dropped by the dog in a public place or in a stormwater drain or channel (whether on public or private land).
>
> Maximum penalty: 5 penalty units.
>
> **(2)** The carer of a dog must not take the dog into a public place or a stormwater drain or channel (whether on public or private land) unless the carer carries equipment suitable for the hygienic disposal of faeces dropped by the dog.
>
> Maximum penalty: 1 penalty unit.
>
> *Domestic Animals Act 2000*

The clear limitation to this requirement is the lack of enforcement. However, most members of the public (personal observation) are willing to dispose of faeces as long as it is convenient. They dislike having to carry plastic bags containing faeces for long distances. The provision of more bins for faecal (and other waste) disposal in areas frequented by dogs and their owners has been shown to increase compliance rates.

Government can encourage compliance with current moves to ban plastic shopping bags by supplying biodegradable “poo bags”, available from a number of sources, together with biodegradable bin liners in special “poo bins”. These bins are

[1] Dr John Sheehan 3 Prell Pl Hackett, 6248 0376, 9427 1140

distinctive, advertise the service provided by government, can be sponsored by local businesses, and tend to be ignored by vandals because of the association with dog faeces. Even normal litter bins will be used for faeces disposal if available. Special clip on bags for carriage of "poo bags" are also available and are commonly provided by councils with dog registration to encourage compliance with laws requiring removal of faeces. These are printed with messages and sponsors logos, and could be sponsored by local businesses and organisations.

Dogs can also be encouraged to eliminate in areas away from those used by the public. Many councils have installed "pooch patches" to attract dogs to toilet there – usually a patch of sandy soil (for drainage) with posts to attract male dogs, and a litter / poo bin nearby([123]). Placing these near the entrances to areas frequented by dogs being exercised will encourage elimination there, rather than in areas shared with humans. Dogs are also more likely to defaecate in long grass than in short grass – maintaining grass short adjacent to walking paths but with long grass nearby will encourage dogs to defaecate there, rather than where people walk and play.

Finally, the provision of more, dedicated, dog exercise areas, especially safe off leash areas will attract dogs and their owners and reduce the use of sporting fields by dogs. If such areas are fenced, they will be much more attractive to dog owners (safety aspects) and contain dog faeces within the area. Clearly, owners should still be encouraged and required to clean up after their dog.

<u>Further reading (especially *):</u>

Leather RL 1994 "Legislation for urban animal management: experience with formulation and implementation of Scoop Law" National Urban Animal management Conference, Canberra, Australian Veterinary Association

Jackson, Virginia 1995 "Guidelines for designing and managing public open space" National Urban Animal management Conference, Melbourne, Australian Veterinary Association

Pert, Terry-Ann 1996 "Initiatives for the environment" National Urban Animal management Conference, Sydney, Australian Veterinary Association

Jackson, Virginia 1997 "Turning theory into practice Banyule City Council" National Urban Animal management Conference, Adelaide, Australian Veterinary Association

*Jackson, Virginia 2000 "Faecal litter management - a local government priority for reasons of community health and environmental amenity" National Urban Animal management Conference, Hobart, Australian Veterinary Association

all available at http://www.uam.net.au/pages/PUB_ConPro.htm,

Conclusion

This review has shown that dog faeces may contain a variety of organisms which are pathogenic for man. It is clearly appropriate that the risk be reduced. However, the methods chosen must be due to a demonstrable need, and be cost effective and practical.

The incidence of parasites, bacteria and viruses is low in Canberra dogs due to a general high level of care by owners and our relatively high socio-economic status. Most dogs are fed commercial foods, reducing the risk of food borne pathogens. Most dogs are wormed regularly, minimising the risk they will be passing worm eggs in their faeces. Most dogs are not exercised when they are passing diarrhoeic faeces, reducing (but not eliminating) the passage of zoonotic bacteria. It is my experience that the dogs who are cared for by more responsible dog owners, who seek regular veterinary care and apply routine health management such as worming, are more likely to be exercised than are those dogs whose owners do not undertake such a responsible level of management. A higher risk for most of these organisms would be associated with faeces from stray dogs and foxes. One individual stray dog or fox infected with *Echinococcus granulosus* could contaminate a large area or sporting and other public areas with dangerous eggs.

Infectivity of parasite eggs and other organisms is limited by their survival and ability to maturate. Most organisms are destroyed or unable to become infective if they are desiccated, as is likely in Canberra summers, particularly with reductions in water applied to sporting fields. Many organisms are temperature sensitive and will not survive or mature in winter temperatures, or when temperatures are too high. Some organisms become unavailable when faeces break down and are incorporated into soil.

Humans with normally functioning immune systems are at much less risk for most of the disease discussed than are young children, or those with incompetent immune systems. It is presumed that those with immunodeficiency diseases such as AIDS, or whose immune systems are affected by immuno-suppressive or anticancer drugs, are less likely to be active on sporting fields, and their greatest risk is in the home from their own pets. Children are probably most at risk at ages where they "play in the dirt" in sand pits and the like, rather than once they start to play sport, but clearly some children of susceptible age will use sporting fields and other public parks.

The risks to humans of dog faeces on sporting fields must also be balanced against the benefits to humans of exercising dogs. For many people, the time spent exercising their dog is the main exercise they get. Health benefits of pet ownership include reduction in stress, increased survival after cardio-vascular accidents and reduction in blood pressure. Pet owners make fewer visits to the doctor, amounting to an estimated saving of $3.86 billion to Australia's annual health budget [124]. This probably equates to a direct saving of $50 million to the ACT's health budget. For many people, dogs are their main companions and friends, and one of their few links into society. A person walking a dog has been shown to be five times more likely to engage in conversation than someone walking alone[125]. Banning dogs from sporting fields will clearly not obviate these benefits, but may reduce them.

Unless a higher level of enforcement is available, one must also question the practicality of banning dogs from such areas. In many cases, sporting fields are the main open area available to dog owners, or are “on the way” to other more desirable locations. It will be very difficult for DAS or other CUPP staff to patrol these areas and enforce a ban.

A programme of education and encouraging compliance with existing laws seems much more appropriate. Most pet owners are willing to “do the right thing” if they understand why, and if it is made easy for them. The animal industry including veterinarians would support and participate in initiatives which encouraged a higher level of responsible pet ownership, including health care and faecal disposal. In addition, areas of higher risk such as children’s play areas should have more effective dog exclusion provisions including effective fencing.

In my opinion, the risks to humans of dog faeces on sporting fields do not justify the banning of dogs from these areas, and recommend that the government take other measures to minimise the small risks which do exist.

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