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The Zoonotic Potential of Dogs in Aboriginal Communities in Central Australia

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This article reviews the established zoonoses from dogs, and identifies the potential burden of speculative zoonoses of canine origin in Aboriginal communities in Central Australia. A variety of organisms such as bacteria, viruses, and parasites including protozoa, ectoparasites and helminths (worms) have possible zoonotic capability; these organisms are discussed. Observational research was conducted in seven Aboriginal Town Camps of Alice Springs to describe the human and dog interactions and behaviours, and risk factors for transmission. Information was also gathered on the cultural significance of dogs to Aboriginal people in the community under observation. The relationship between Aboriginal people and their dogs appears to be not only one of companionship, but involves other more complex cultural factors. The contribution dogs make to infections and infestations of Aboriginal people in communities throughout Australia remains unclear. Education and dog health programs have an important role in reducing the risk of canine-related human morbidity in Aboriginal communities.

Key words: Dogs; Zoonosis; Aboriginal Health; Indigenous Australians

Infectious diseases transmissible between humans and animals are termed zoonoses, or zoonotic diseases. They are caused by bacteria, viruses, fungi, parasites and helminths (Currie 1995). The variety of animal hosts varies greatly, as do modes of transmission from animals to humans. In Australia, animal sources of zoonoses include cattle, sheep, horses, kangaroos, birds, dogs and rodents (Stevenson & Hughes 1988). In particular, Schantz (1991) highlighted more than a decade ago that the potential health risk to humans of enteric parasites harboured by the pet dog is a significant problem. The incidence of zoonoses transmitted from pets to humans depends on a number of factors (Raw 2001):

- The number of animals in and around the home environment
- The human and animal behaviours and extent of interaction
- The route and efficiency of transmission from pets to humans

- Existing measures to prevent transmission.

The impact on public health of zoonotic infections can also be ranked according to the severity of disease. Although it is suggested that none of these are major causes of mortality, they impose a heavy burden in terms of human morbidity (Robertson et al. 2000; Schantz 1991).

The health status of Aborigines and Torres Strait Islander Australians lags behind that of Australians generally (AIHW 2006). Despite much effort over the past two decades, the life expectancy of Aboriginal people remains 17 years behind the non-Aboriginal population of Australia (Condon et al. 2004; Wilson et al. 2007). The health problems of Aborigines vary across Australia, reflecting the different circumstances of communities. There are many remote Aboriginal communities scattered across central and northern Australia. These communities have populations ranging from less than 100 to a few thousand, frequently living in harsh conditions (Currie 1998).

Overcrowding is common and sometimes 10 or more people may share a single house with a poor water supply and inadequate sanitation (Currie 1998). Intestinal and skin infections and infestations remain a major cause of Aboriginal ill-health and of hospitalisation (Currie & Carapetis 2000).

The possible health risk to humans of organisms harboured by the domestic dog is potentially of great importance to Indigenous communities across Australia. In such regions people commonly share their home environment with a variety of animal species that inevitably leads to frequent inter-species exposure to potential zoonoses (Raw 2001; Robertson et al. 2000). The issue in any context where dogs and humans interact is how much infectious disease transmission is the result of zoonoses compared with other environmental sources? The health impact of these interactions in Aboriginal communities across Australia is a point of ongoing discussion. It appears that the implication of close contact between Aboriginal people and their dogs not only involves issues of public health importance, but also the social health and wellbeing of Indigenous communities (Currie 1995; Senior et al. 2006).

The purpose of this paper is to review the 'evidence' for association between the disease burden of domestic dogs and Indigenous health in Central Australia. The literature review looks at the established zoonoses from dogs, and the potential burden of speculative zoonoses of canine origin. This is supplemented with insight from research in Central Australia observing interactions and behaviours of community members and their dogs, and addressing the significance of dogs in aspects of Aboriginal culture.

Methods

This research consists of two components: a literature review to determine the established zoonoses from dogs, and to identify the potential burden of speculative zoonoses. The results of this review are considered in the

light of observations made in the four week field research. The project was a pilot study undertaken at the request of Tangentyere Council (an Aboriginal organisation) in Alice Springs. Tangentyere Council is an Incorporated Body established to manage on behalf of Aboriginal owners of land, Leases in Perpetuity for 18 Housing Associations (known as Town Camps) on the outskirts of Alice Springs.

Field research was conducted in June and July 2001 in Alice Springs, Northern Territory, and comprised direct observation of seven Aboriginal Town Camps within the Alice Springs area. Camps participating in the study were selected by committee members of Tangentyere Council following consultation with community members. Observational data collected included details of human and canine interactions and behaviours within the Town Camps, and visual indicators of the animals' general health. Information was also gathered on the cultural significance of dogs to the community. Ethics approval was provided by the Central Australian Human Research Ethics Committee, Flinders University Social and Behavioural Research Ethics Committee, and Tangentyere Council Ethics Committee in Alice Springs. Field research was conducted with the assistance of Tangentyere Council members and the Centre for Remote Health in Alice Springs.

Results

Field observations

The population of Aboriginal residents varied significantly between the Town Camps under observation, ranging from 40 to 160 (mean 94). The number of houses occupied by residents of the Town Camps ranged from 7 to 22 (mean 14), meaning approximately 5 to 7 individuals resided in each home within each Camp observed. Observations of the total number of dogs recorded at each camp over the test period showed variation between 5 to 42 dogs (mean 18). For individual Town Camps this represents an average of between

1 and 3 dogs per household, although some households had up to 10 dogs.

Observational data were also collected regarding the interaction and behaviours of both human and canine populations. As mentioned, numerous inhabitants were often observed in a single dwelling. The majority of Camp inhabitants were observed outside their homes during the visits, often sitting on verandas or front yards. In many cases this was due to the extended family network cohabitating. There seemed to be partial domestication of dogs, with many needing to forage for their own food. Partial fencing or boundaries around homes were only observed at one Town Camp. Dogs appeared to have free access around the Camps and in many cases had access indoors. Many of the animals were observed with mange on their coats indicating possible scabies infestation. Close association between dogs and humans in the Aboriginal community was observed. In particular, children were often observed in close proximity to several dogs at one time, frequently engaging in contact with them. Children in particular seemed to have considerable contact with dogs in their extended family network. The observed pet-human interactions in the Aboriginal community show the potential for transmission of canine disease to humans.

Review of literature on zoonoses between dogs and humans

Numerous organisms are recognised in the literature as having zoonotic potential. A summary of these organisms is provided in Table 1, including their transmission routes and ranked evidence of zoonoses from dogs. Each organism is then discussed by group in terms of their zoonotic capability, and potential disease burden to Aboriginal communities in Australia.

Ectoparasites

Scabies, the disease associated with *Sarcoptes scabiei*, is due to the reaction of the host to the mite or its products (Shield 1996).

In Aboriginal communities in northern Australia, scabies is endemic in both human and dog populations (Walton et al. 1998). The problem seems to have worsened in recent years, with prevalence in children at times over 50% and in adults up to 25% (Currie & Carapetis 2000). As a result, community based programs have been initiated in order to improve health outcomes. One such program has been developed by the Cooperative Research Centre for Aboriginal Health (CRAH). The goal of the *Healthy Skin Program* is to reduce the prevalence and impact of scabies and skin sores in Indigenous communities.

In terms of risk factors for infection, it has been suggested that scabies infestation is not related to hygiene, but is strongly associated with overcrowding (Currie & Carapetis 2000). This risk factor is of importance in the community under observation, where many inhabitants were observed in a single dwelling. Research suggests that the role of bedding and clothes (known as fomites) in disease transmission is not as important as close body contact (Currie & Carapetis 2000). Aborigines have a close association with their dogs, as suggested in the current study (see *Totemic Dreaming*), and many animals were observed with the appearance of mange on their coats. As a result of this close contact between people and dogs, the possibility of dogs being a reservoir for human infection has been suggested, and has become the rationale for introducing dog treatment programs in some communities (Tindall 2001).

Past studies around the world have documented incidents of canine scabies spreading to humans (Charlesworth & Johnson 1974; Mitra et al. 1993). Diagnosis in many of these cases was based on classical identification methods (e.g. morphology) of the scabies variant from the affected animals rather than more rigorous identification methods. Recent advances in molecular typing methods for scabies mites have enabled an initial investigation into the differences

Table 1: Organisms recognised as having zoonotic potential; their transmission route and ranked evidence of zoonoses from dogs

Organism	Transmission route	Evidence of zoonosis from dogs
Ectoparasites:		
<i>Sarcoptes scabiei</i> (scabies)	Close contact	Strong historical evidence; emerging evidence for host specificity
Helminths:		
<i>Ancylostoma caninum</i> (hookworm)	Stool (eggs or larvae) to soil to skin (via infective larvae)	Strong evidence
<i>Toxocara canis</i> (roundworm)	Stool (eggs or larvae) to soil to accidental ingestion	Strong evidence
<i>Trichuris vulpis</i> (whipworm)	Stool (eggs or larvae) to soil to accidental ingestion	Weak (presumptive) evidence; no evidence in Australia
<i>Strongyloides stercoralis</i> (threadworm)	Stool (eggs or larvae) to soil to skin (via infective larvae)	Weak evidence
<i>Dipylidium caninum</i>	Accidental ingestion (cysterci); fleas and lice intermediate hosts	Weak evidence
Protozoan:		
Giardia	Faecal-oral (dog or human)	Weak circumstantial evidence; humans main reservoir.
Cryptosporidium	Faecal-oral (dog or human); contaminated water supply	Weak evidence; other sources predominate
Bacteria and Viruses:		
Campylobacter	Faecal-oral (dog or human); food, milk or water	Weak evidence; human-to-human thought to predominate
Rotavirus	Faecal-oral (dog or human)	No established link; current evidence against it.

between the canine and human variants (Walton et al. 1999). The findings by Walton et al. (1999) is in contrast to historical evidence and suggests that the vast majority of cases of scabies in the current epidemic in Aboriginal communities show clear genetic separation between mites from humans and those from dogs. Walton et al. (2004) have since extended on previous investigations, with recent data clearly supporting previous work that scabies mites on people are genetically distinct from those on dogs. More epidemiological evidence is required to document accurately the proportion of illness caused by the dog scabies variant residing on human skin, compared with infection due to human-associated scabies variant. Scabies control programs should continue to focus on

human-to-human transmission as a source of infection for this organism.

Helminths

Aboriginal children in Australia frequently suffer from infestation with intestinal parasites (Prociv 2001; Stuart 1990). Prevalence levels in some remote Australian Aboriginal communities compare with those in developing countries (Prociv 2001). Five helminths (4 nematodes and 1 cestode) of dogs in northern and central Australia have recognised zoonotic potential (Shield 1996). For nematodes, these are the dog hookworm, *Ancylostoma caninum*, the dog roundworm, *Toxocara canis*, the dog whipworm, *Trichuris vulpis*, and *Strongyloides stercoralis* in the gastrointestinal tract; for cestodes, *Dipylidium*

caninum has the potential to infect humans.

Recent parasitological surveys of dogs have indicated that the prevalence of intestinal helminths has declined over the last 20 years in the developed world (Robertson et al. 2000). This might be a real decrease associated with the ready availability and adoption of safe and effective drugs to eliminate these infections from pets (Robertson et al. 2000). Alternatively, differences in sampling protocols including source and age of animals, prior antihelminthic usage in sampled animals, diagnostic techniques, or environmental conditions between surveys, might account for the decrease in prevalence (Robertson et al. 2000).

Of particular concern with infection with hookworm (*Ancylostoma caninum*) is the fact that single worms have been associated with development of illness (Prociv & Croese 1990; Prociv 2001). Because the hookworm could easily be overlooked in pathological specimens, Robertson et al. (2000) proposed that this condition was likely to be under-diagnosed and might be more widely distributed than is currently appreciated. As with many other zoonoses the faecal-oral route is important in the transmission of this agent to humans. Appropriate hygiene procedures such as hand washing and removal and disposal of faeces will reduce the probability of infection (Currie 1995).

A study in dogs from around Australia found high levels of infection with *Toxocara canis* (roundworm) of up to 45% (Shield 1996). However, the survey involved only small numbers of animals, and thus might not be representative. Bugg et al. (1999) considered that one of the major reasons for the reduction in prevalence of parasites, such as *Toxocara canis* and *Dipylidium caninum*, was a growing awareness by dog owners about these parasites and methods for controlling them.

While it is suggested that control programs have had success with hookworm in Australia, little attention seems to have been paid to

Trichuris and *Strongyloides* (Shield 1996). Both of these are capable of causing serious morbidity, and strongyloidiasis can persist in an individual for decades (Johnston et al. 2005; Stuart 1990). *Strongyloidiasis* remains common in many Aboriginal communities in Northern Australia with prevalence ranging from 0 to 60% (Johnston et al. 2005). Dogs have been implicated as potential infective reservoirs for *Strongyloides*, although the evidence of dogs as a source of human infection is not convincing (Prociv 2001). Person to person contact in particular with children remains the main mode of transmission. The sustained effects of treatment, particularly noted in children (Prociv 2001) seems to preclude other major sources of infection.

It appears there is a need for increased awareness about the illnesses helminths cause and the potential role of close contact with dogs in their transmission. Although zoonotic infection of humans is believed to be a rare occurrence (other modes of transmission predominate), it is a factor of relative importance in Aboriginal communities and merits further study. The role of host-species specificity in human infection is unknown. Canine strains, while similar to human strains morphologically, might be distinct species, and ongoing molecular research will help clarify the zoonotic capability of these organisms.

Protozoan pathogens

The intestinal flagellated protozoan *Giardia* is ubiquitous and infects large numbers of human and animal hosts worldwide (Isaac-Renton et al. 1993). In Australia, Giardiasis is considered to be the most important parasitic disease in terms of morbidity, in particular as a cause of diarrhoea in children (Thompson 2004). Australian studies have shown that *Giardia* infections have a high prevalence in both humans and dogs, from metropolitan and remote areas (Hopkins et al. 1997; Meloni et al. 1993; Thompson

2004). Dogs may therefore be identified as a potential reservoir for human infection, and should Giardiasis eventually prove to have a zoonotic capability, dogs may provide a significant and ready source of human infection (Hopkins et al. 1997; Monis & Thompson 2003).

As dogs have a very close traditional association with Aboriginal people and have been shown to carry *Giardia* species they may transmit infection by close contact (Meloni et al. 1993). The presence of multiple dogs in a household was identified by Bugg et al. (1999) as increasing the chance of dogs being infected with *Giardia*. Observations regarding the numbers and risk behaviour of dogs, and their interaction with humans in Aboriginal communities have helped to clarify the possibility of zoonotic transfer. Epidemiological evidence suggests that humans are likely to be the main reservoir of human Giardiasis and it is likely that direct person-to-person transmission is more important than zoonotic transmission (Monis & Thompson 2003), however, dogs may carry strains of *Giardia* with the potential to be infective to humans (Hopkins et al. 1997; Thompson 2004).

It remains to be established whether there are distinct host specificities with regards to sub-species of *Giardia* (Thompson 2004) and further epidemiological studies using new genotyping techniques might answer this question. Nevertheless, the potential for dogs to act as reservoirs of human infections is clearly demonstrated, and continues to be of particular significance in Aboriginal communities where close interaction between dogs and humans is observed.

Cryptosporidium is another common protozoan and cause of human diarrhoea (Currie 1995). *Cryptosporidium* has also been detected in dogs, which might represent an important reservoir of infection for humans (Bugg et al. 1999). Molecular studies have indicated that *C. parvum* is not a single uniform species but instead composed of

at least six genetically distinct genotypes, only two of which appear to be capable of infecting humans (Morgan et al. 2000). Although people of all ages are at risk for exposure to *Cryptosporidium*-infected dogs, younger children are at a higher risk (Fayer 2004). Close human-dog interactions as observed in the current study present the risk of exposure to agents such as *Cryptosporidium*. In addition, the ability of infective oocysts to survive in the environment for extended periods increases the potential of exposure (Fayer 2004). Overall, research suggests *Cryptosporidium* species have possible zoonotic implications in tropical Australia (Currie 1995; Monis & Thompson 2003), and close contact with puppies in particular might increase the risk of exposure (Morgan et al. 2000; Schantz 1991). Further genetic and biological studies are required to determine fully the prevalence, transmission dynamics, and species status of the *Cryptosporidium* 'dog' genotype.

Bacteria and viruses

Campylobacter infection has one of the highest rates of all notifiable diseases in Australia (Tenkate & Stafford 2001). Of these, *Campylobacter jejuni* is recognised as presenting possible zoonoses from dogs, although other animal sources, contaminated food and water, and direct human-to-human spread are thought to be the predominant transmission modes (Cook 1989; Tenkate & Stafford 2001). The true role of *campylobacteria* in human gastroenteritis is probably significantly understated as most routine diagnostic laboratories do not use isolation techniques which would detect the more fastidious and demanding species (Baker et al. 1999). However, recent advances in the molecular characterisation of different *Campylobacter* strains, and the creation of databases containing *Campylobacter* fingerprints, will allow the comparison of strains and give a basis for tracing back the origin (Keller et al. 2007).

Campylobacter gastrointestinal infections in Aboriginal children are well documented (Currie 1995; Hanna 1994; Stevenson & Hughes 1988). A recognised risk factor for zoonotic infection in humans is close proximity to dogs, in particular puppies (Hanna 1994; Tenkate & Stafford 2001). In the current study, children had considerable contact with dogs in their extended family network. The close affinity between Aboriginal people and their dogs might help to explain high rates of *Campylobacter* infections in Aboriginal children (Currie 1995; Hanna 1994). A difficulty in attributing human cases to contact with animals is that *Campylobacter* will be present in animal intestine, regardless of their involvement in human disease (Stevenson & Hughes 1988). Regardless of the means by which dogs become carriers, animals carrying *Campylobacter* spp. are certainly a potential source of infection for humans (Baker et al. 1999; Keller et al. 2007). It is appropriate to further document information on *Campylobacter* species as a cause of enteric disease in dogs, and as a possible reservoir for infection in humans.

A group of antigenically related viruses, called rotaviruses, have been demonstrated in the faeces of humans and a wide range of mammalian species (Stevenson & Hughes 1988). In Australia, about half of the 20,000 hospital admissions annually for acute diarrhoea in children under 5 years are due to rotavirus gastroenteritis (Gelbart et al. 2006). The disease burden in Aboriginal communities is particularly marked with rates of hospitalisation for rotavirus in communities in the Northern Territory 3 to 5 times higher than other Australian regions (Gelbart et al. 2006). Rotaviruses are well recognised as being transmitted directly and indirectly from human-to-human, with only a small number of particles required to initiate infection (Desselberger 1999). As a result rotaviruses can spread easily under conditions of overcrowding and poor

hygiene (Desselberger 1999). To date there is no established link to zoonotic disease from dogs (Cook et al. 2004; Currie 1995; Nakagomi et al. 1990). A study over a decade ago was successful in identifying rotaviruses of closely related feline and canine origin, but whether animal strains can infect humans has yet to be resolved (Nakagomi et al. 1990), and current evidence seems to suggest it is not likely (Cook et al. 2004; Currie 1995). Regardless of the ambiguity in source of human infections by this pathogen, it appears to be of continuing public health significance in the community under observation in this study. This is particularly so as many people observed lived under conditions of overcrowding and poor hygiene, which aids in the rapid spread of this agent (Desselberger 1999). Further research is required to understand the genetic diversity of human and animal rotavirus genomes, in order to evaluate its significance as a zoonotic agent.

With regard to the control of this and other zoonotic infections, social wellbeing might also be an important issue due to the relationship between Indigenous people and their dogs, as explained below.

Totemic dreaming

To understand fully the dog health and human health in Aboriginal communities, an appreciation of the cultural and historical context is needed. Senior et al. (2006) provide an excellent review of the anthropological literature concerning people's relationships with dogs in Aboriginal communities. The authors explore this relationship within the context of the social determinants of health. It seems the relationship between Aboriginal people and their dogs is partly one of companionship but involves other more complex cultural factors. Some Aboriginals believe that their ancestors might return as animals (in particular as dogs) and so there is reluctance to destroy them even when they are ill (Shield 1996). Traditional Aboriginal

custodians of Alice Springs in the Northern Territory of Australia are Arrernte people. In Arrernte tradition every part of the Alice Springs topography has a name and a totemic association with one of the ancestral beings which in Arrernte culture originally travelled through the area creating features (Brooks 1991). The major totemic association is that of the wild dog. In Arrernte culture, many of the features of the west side of Alice Springs were formed by the activities of the wild dog. For these reasons, these animals remain an integral part of the spiritual life of the Arrernte people.

Management Programs

Over the last decade there have been numerous programs implemented to improve the health of dogs in Indigenous communities and as a result, to improve the health of the people in those communities (Raw 2001; Tindall 2001). These programs have involved varying combinations of parasite control (in particular scabies), surgical desexing and medical contraception for population control, and other initiatives (Bradbury & Corlette 2006).

Since infections of dogs and humans are often the result of human activity, education must also play a key role in their control. Increased awareness that some diseases might be associated with dogs, and more effective prevention and treatment programs, will help to reduce the prevalence of zoonotic infections and infestations. In a recent conference, an Action Plan for Companion Animal Health Programs was

drafted by Animal Management in Rural and Remote Indigenous Communities (AMRRIC) (Aboriginal and Torres Strait Islander Commission 2000). The Plan covered cultural and social concerns, as well as dog and human health, and education and training. Recommendations were made including a move beyond the current 'band-aid' reactive approach towards a more sustainable, proactive and preventative approach. It also highlighted the need for incorporating education and community involvement in dog health programs in Indigenous communities across Australia.

Conclusion

Factors that influence human infection with zoonotic organisms appears to vary depending on the genus and even species of the organisms involved. Ongoing studies utilising new molecular techniques will help clarify the important issues of host-species specificity and the zoonotic capability of key organisms described in this paper. It is important to consider the continuing occurrence of these diseases in the absence of dogs, and the abundance of literature connecting these diseases with overcrowding, poor hygiene, and other risk factors. Dogs remain an important public health issue in Aboriginal communities of Australia. Ongoing community-focused management and education programs will potentially reduce the prevalence of zoonotic infections and infestations. If this is achieved then dogs will continue to be integral members of healthy Aboriginal households throughout Australia.

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