

Science for Saving Species

Research findings factsheet

Project 1.4.2



National Environmental Science Programme

Toxoplasmosis and mammal declines in northern and southern Australia

In brief

Toxoplasmosis is a disease caused by the pathogen *Toxoplasma gondii*. Cats (*Felis catus*) are the primary host, but to complete its life cycle an intermediate host is usually involved, typically a mammal.

Infected animals can experience a spectrum of clinical signs, ranging from no signs at all to severe sickness or death, and surviving individuals can exhibit behavioural changes that may reduce their chances of survival. As such, toxoplasmosis has been put forward as a possible driver of the well-documented declines in mammal species in northern

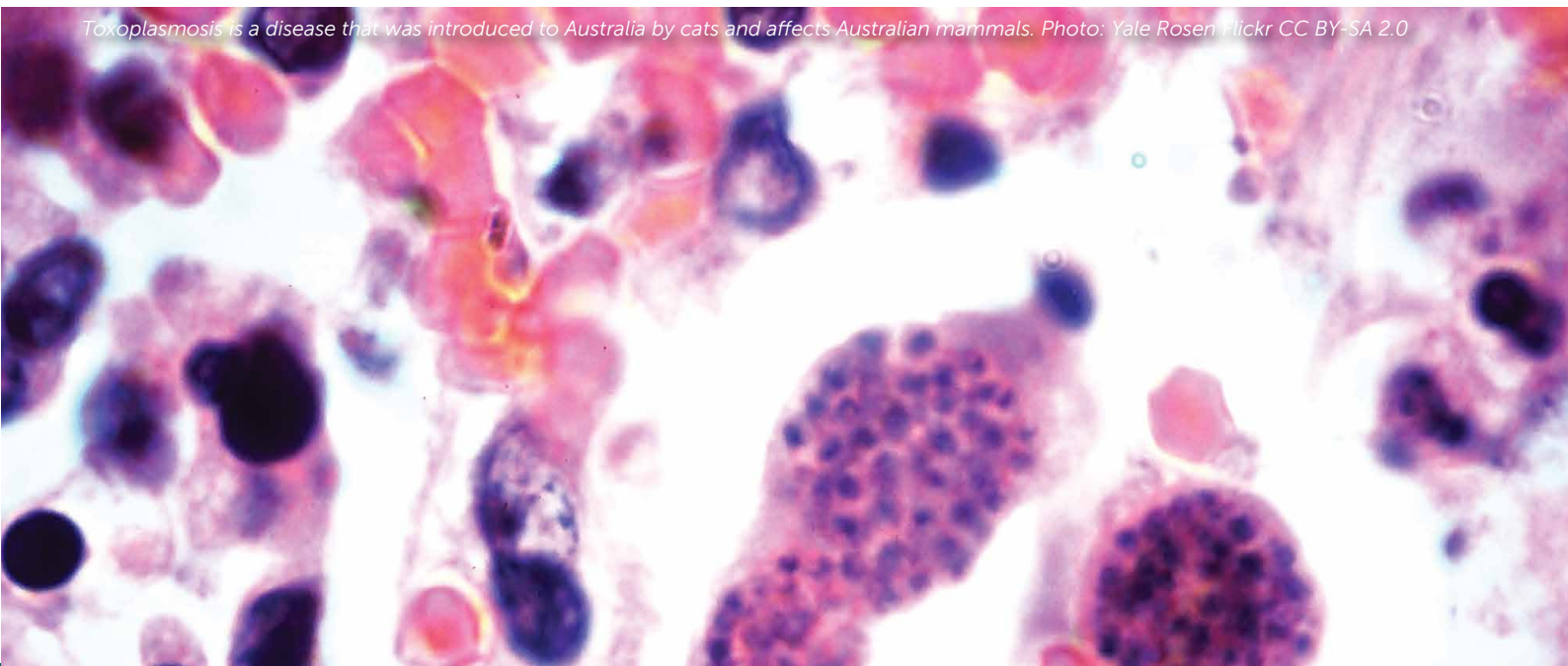
Australia over recent decades. We set out to investigate if *T. gondii* might have played a role in these declines.

Our study is the first to investigate the prevalence of *T. gondii* across Australia and how it is influenced by environmental variables. We found that prevalence varied greatly across Australia, with greater concentrations in southern, eastern and more urban areas. We found that the high ambient temperatures and low rainfall of northern and central Australia are associated with reduced prevalence across those regions.

We conclude that *T. gondii* is therefore unlikely to be a driver of the northern mammal declines, although its prevalence elsewhere could have important implications for conservation managers working with small or threatened populations of ground-dwelling native mammals.

The infection is common in urban areas nation-wide and has serious implications for human and pet cat health. Roaming pet cats risk much greater exposure to this pathogen than do indoor-only pets, so pet owners should be strongly encouraged to keep domestic cats indoors at all times.

Toxoplasmosis is a disease that was introduced to Australia by cats and affects Australian mammals. Photo: Yale Rosen Flickr CC BY-SA 2.0





Background

Wildlife disease has emerged as a critical issue in conservation biology globally. Disease is listed among the top five causes of species extinctions around the world, and the evidence suggests that the risks of disease are escalating.

Wildlife disease has been suggested as a possible cause of the decline in mammal species across northern and central Australia over recent decades. This is because the declines in those regions over the period appear to have occurred

(1) independently of the arrival of cane toads (*Rhinella marina*); (2) well after fire regimes have been altered; (3) within national parks where no new land clearance has occurred; and (4) without documented changes in red fox (*Vulpes vulpes*) or feral cat populations.

Novel pathogens are of concern in Australia, with our fauna potentially vulnerable to their effects due to long geographical isolation. In recent years, researchers have increasingly been giving attention to the hypothesis that novel pathogens have caused historic (primarily 1890–1950) and

contemporary declines in the numbers of Australian wildlife.

Toxoplasma gondii, which causes toxoplasmosis, is one pathogen that researchers have proposed as a possible cause of these declines. It was introduced to Australia with cats, which are the definitive host of the pathogen; however, it also needs an intermediate host, which is also typically a mammal.

Symptoms of toxoplasmosis in native fauna include poor coordination, blindness, lethargy, respiratory and intestinal distress and, potentially, sudden death. Trials on laboratory rodents have shown that it can also reduce fertility, influence mate choice, change sex ratios, increase risk-taking behaviour and reverse the innate avoidance of rodents to cat odours. This “fatal attraction” increases the risk that an infected animal will put itself in the path of a cat, making it easy prey.

But while *T. gondii* is often detected in wildlife and feral and domestic cats, until this study, there has been limited information on its distribution or prevalence across different regions of the country.

Research aims

We aimed to model the distribution and prevalence of *T. gondii* in feral cats across Australia, and explore the relationship between the prevalence of *T. gondii* and a range of environmental variables that are likely to affect its transmission from cats to wildlife (e.g., via infective oocysts).

Using data on the prevalence of *T. gondii* in feral cats to indicate the likely exposure of native wildlife to the pathogen, we aimed to explore the possible relationship between native mammal declines and the disease caused by *T. gondii*, toxoplasmosis.

What we did

We developed a network of land managers across Australia who collected tissue samples (314 in total) from feral cats culled during routine feral animal control. Sample collection began in 2016, and concluded in late 2019. We then screened these tissue samples for *T. gondii* and complemented this primary data with published data on the prevalence of *T. gondii* in an additional 862 cats.

Creating a climate model enabled us to explore the relationship between the prevalence of *T. gondii* and mean annual temperature and rainfall and their interactions, urban versus non-urban areas, and cat density in the wet season. We used this model to create a species distribution model of the predicted prevalence of *T. gondii* in feral cats in Australia.

The environmental variables were chosen for their potential relevance to the transmission of *T. gondii* from cats to wildlife (e.g., via infective oocysts). Urban status is among them because the altered climatic conditions and greatly increased density of cats in urban areas have the potential to influence *T. gondii* prevalence. For example, the urban heat island effect can influence temperature, garden watering can influence moisture, and urban trees can increase shade; and there are generally 100–200 times more cats per km² in urban areas than natural environments due to the high density of pet cats plus increased availability of food for feral cats.



Our findings

Approximately 40% of our sampled feral cats were infected with *Toxoplasma*, but we found that *Toxoplasma* prevalence in cats is highly variable across Australia. The main predictors of prevalence were air temperature, rainfall and urbanisation and, in urban areas, cat density was also influential.

Modelling predicted the parasite to be more prevalent in southern Australia – Victoria, Tasmania, eastern New South Wales and south-east Queensland, and south of Perth in Western Australia – where conditions are cooler and wetter.

Toxoplasma can survive warmer conditions to some extent, as long as there is enough moisture. There was an intermediate prevalence along the eastern Queensland coastline from Brisbane to Cape York due to the increased rainfall along the coast.

Prevalence was much lower in northern and central Australia due to increased temperature and decreased rainfall.

We conclude therefore that *T. gondii* is unlikely to be a driver of the northern mammal declines, although it potentially poses a more

serious risk to native species in the cooler, wetter areas of the country, especially in Tasmania, Victoria and New South Wales.

The additional moisture of park and garden watering, plus high cat densities made urban centres hot spots of prevalence as far north as Darwin and Cairns. There is no evidence of high prevalence outside of urban regions in the north of Australia.



Figure 1. Predicted prevalence of *T. gondii* in non-urban feral cats in Australia from generalised linear modelling based on: annual mean temperature; annual mean precipitation; cat density; urbanisation; and the interaction between these variables. Urbanisation set to zero in this projection.

Implications

The prediction of greater prevalence of *T. gondii* in the southern, wetter areas of Australia, is of most importance to conservation managers working in those regions, especially managers working with ground-dwelling mammals of small or threatened populations, and those coordinating (re)introductions into areas with feral cat populations.

The findings are also important to conservation managers in northern Australia, in that they make toxoplasmosis less likely to be playing a role in the northern mammal declines. We note, however, that there are still opportunities for spill-over from urban cats to feral cats in northern Australia (and elsewhere).

By acting as reservoirs for *T. gondii* in otherwise unsuitable regions, urban areas may also allow the parasite to adapt to the environmental conditions of these otherwise unsuitable regions. This could occur as urban areas will supply a steady stream of *Toxoplasma* oocysts

into surrounding areas (in cat faeces), the oocysts will be exposed to challenging environmental conditions on the edges of urban areas and, while most will perish, over time genetic variations may occur allowing some oocysts to survive until they are consumed by a secondary host. Natural selection will ensure that those best adapted survive to reproduce.

The threat of urban areas supporting adaptation of the parasite to hotter and drier conditions therefore provides an additional conservation-focused incentive to control feral animals in hot, dry urban areas.

Although *T. gondii* prevalence is predicted to be low in hotter, drier areas of Australia, local outbreaks of toxoplasmosis might still occur if environmental conditions are suitable (e.g., during wet periods or around watercourses), and especially if there is spill-over from urban cats to feral cats. Targeted biosecurity efforts might be required to protect vulnerable populations when environmental conditions are likely to support increased survival of *T. gondii* oocysts in the environment.

Our findings are also important for owners of domestic cats in the southern regions of Australia. Toxoplasmosis is a serious disease in cats that can require veterinary treatment, and it can also be transmitted to humans, where it can cause miscarriage in pregnant women and hospitalisation of healthy adults. Free-ranging

domestic cats are at higher risk of exposure to this pathogen than indoor-only pets, and may act as a disease reservoir in populations, increasing the prevalence of *T. gondii*. Pet owners should therefore be encouraged to keep domestic cats indoors at all times.

Our findings are similarly important for livestock farmers across the country. Toxoplasmosis is a serious disease for livestock, and especially sheep, with infection causing stock losses via abortion and weakened offspring. Livestock Infections are also a public health issue, as the disease can be transmitted to humans via the consumption of infected meat. Our predicted prevalence of *T. gondii* in feral cats can be used to inform risk assessments in livestock on a broad geographic scale, and potentially also finer scales (e.g., with rainfall, topography).

The virulence of *Toxoplasma* strains varies greatly in intermediate laboratory and agricultural hosts; while little studied, there is some evidence that strain type also predicts disease severity in native wildlife. Information on the diversity and distribution of *T. gondii* strains across Australia remains lacking, however. Further research on the impact of *T. gondii* on disease outcomes in native wildlife, coupled with genotyping of *T. gondii* across the country, would therefore provide greater insight into the risk of *T. gondii* to native wildlife.

Cited material

Dickson, J.A. (2018) The distribution of *Toxoplasma gondii* in Australia. Honours Thesis, School of BioSciences, University of Melbourne.

Further Information

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