Gastrointestinal parasites of feral cats from Christmas Island

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Objective To investigate the gastrointestinal parasites present in feral cats on Christmas Island, with particular interest in the protozoan parasite *Toxoplasma gondii*.

Procedure Faecal and serum samples were collected from 28 and 25 cats respectively that were trapped as part of an ongoing eradication program being run on Christmas Island by the Department of Environment and Conservation. Faecal samples were screened microscopically for helminth and protozoan parasites. Serum samples were screened for antibodies to *T gondii* using a commercial indirect immunofluorescence assay (IFA) and a latex agglutination test (LAT).

Results The most common helminth parasites detected were *Toxocara cati* (present in 15 of 28 faecal samples), *Strongyloides* sp (13/28), *Aelurostrongylus abstrusus*, (7/28), an unidentified capillarid (6/28) and *Ancylostoma* sp (4/28). Based on serology, *T gondii* was the most common parasite detected (protozoan or otherwise) with antibodies detected in 24 serum samples by IFA and 23 serum samples by LAT.

Conclusion Cats on Christmas Island harbour many of the helminth and protozoan parasites reported from feral cats elsewhere in Australia. The high seroprevalence of *T gondii* in these cats indicates a high level of exposure to the parasite in this environment.

Key words: feral cats, parasites, protozoa, *Toxoplasma gondii*

IFA Immunofluorescent antibody assay
LAT Latex agglutination test

The feral cat, *Felis catus*, is well established throughout Australia, including many of its offshore islands. The diet of this highly adaptable predator is as wide and varied as its habitats. It is known to prey upon 186 species of native bird, 64 of native mammal (in addition to introduced mammals), 87 of reptiles, 10 of amphibians and numerous invertebrates.[1–6] The feral cat is a selective feeder that can readily switch prey species depending on relative abundance, allowing it to avoid population decline in unfavourable seasons.[7] Several surveys of the gastrointestinal parasites of feral cats have been conducted in Australia,[8-15] with the species and prevalence of parasites identified varying depending on the available food sources and climate. This study presents information on the gastrointestinal parasites identified from feral cats collected from Christmas Island, a region from which only limited data currently exist.

Christmas Island, with an area of 135 km^2, is in the Indian Ocean at 10°25′S 105°40′E, approximately 360 km south of Java and 900 km north-east of the Cocos (Keeling) Islands. Cats were originally

brought to Christmas Island at the time of first European settlement in 1888 and a feral population became established soon after.[16] The presence of an abundant feral cat population in the Christmas Island National Park, in conjunction with the stray cat population in the settlement, has raised concerns from the island community regarding these nuisance animals and their possible risk to human health as reservoirs of disease.

This study presents data on the occurrence of helminth and protozoan parasites detected in a sample of feral cats from Christmas Island.

Materials and methods

Officers from the Department of Conservation and Land Management trapped and killed 28 feral cats (15 males and 13 females) on Christmas Island as part of a control program. Trapped cats were killed by a single shot to the head with a .22 calibre rifle. The age of individuals was arbitrarily assigned according to weight.[17] Five of the cats captured were juvenile (female ≤ 1.5 kg, male ≤ 2.0 kg) and the rest were mature (female ≥ 1.6 kg, male ≥ 2.1 kg). No kittens were collected in this study.

Faecal samples were collected from each cat after death and preserved in 10% formalin. The samples were transported to Murdoch University and screened for the presence of helminth eggs and protozoa using a modified sugar sodium chloride centrifugal flotation method, [18] to concentrate eggs and cysts. These were viewed via light microscopy at × 100 and × 400 magnification. *Cryptosporidium* oocysts were detected via light microscopy by staining with 5% malachite green stain and visually scanning microscope slides at × 100 and × 400 magnifications.[19] Identification of parasite species was performed based on egg and cyst morphology for the well documented species.[20] Some whole worms were also present in the faeces and these were identified from their morphology.

Blood samples were collected from 25 of the 28 dead cats, and allowed to clot overnight at 4°C before removing the serum and storing at -20°C. Frozen serum was transferred to VETPATH Laboratory Services (Ascot, WA) where an indirect immunofluorescence assay (IFA; Toxo IFA commercial test kit, Fuller Labs) was used to generate titres to *Toxoplasma* IgG and IgM. These results were validated using a latex agglutination test (LAT; Toxolatex® commercial test kit, Laboratoires Fumouze) to detect *Toxoplasma* IgG in the same samples. A titre of 1:64 was regarded as positive for the IFA test and 1:4 for the Toxolatex test according to the manufacturer's instructions.

Results

The most common helminth parasites were *Toxocara cati*, *Strongyloides* sp, *Aelurostrongylus abstrusus*, a capillarid and *Ancylostoma sp* (Table 1). Due to a lack of distinguishing morphological features it was not possible to distinguish the exact species of *Strongyloides* and *Ancylostoma* eggs detected.

Screening of serum samples collected from 25 cats detected antibodies to *Toxoplasma gondii* in 24 (Table 2). Using the IFA with a cut-off titre of 1:64, 24 cats tested (96%) were identified as being exposed to *T gondii*, whilst 23 cats (92%) were identified using LAT. Those positive samples whose IgM titres were equal to or greater than 1:128 indicated a relatively recent exposure (possibly within the last two years), whilst those whose IgM titres were less than 1:128 (1:64 and 1:32), indicated that exposure to *T gondii* possibly occurred two or more years ago. *T gondii* oocysts were not detected in the faeces of any of the cats examined.

Table 1. Helminth and protozoan parasites detected in faecal samples from 28 feral cats from Christmas Island.

Parasite	Number of positive cats
Nematoda	
Toxocara cati	15
Strongyloides sp	13
Aelurostrongylus abstrusus	7
Capillarids	6
Ancylostoma sp	4
Spiruroid sp	3
Physaloptera sp	1
Pterygodermatites sp	1
Strongyle sp	1
Cestoda	
Taenia taeniaeformis	2
Protozoa	
Cystoisospora felis	2
Cystoisospora rivolta	2
Besnoitia wallacei	1
Cryptosporidium	1
Sarcocystis sp	1

Table 2. IgG and IgM titres of 25 serum samples obtained with immunofluorescent antibody assay (IFA) on cats from Christmas Island. IFA titres of 1:64 and greater were scored as positive.

Titre	< 1:32	1:32	1:64	1:128	1:256	1:512	> 1:512	Prevalence
IgG (IFA)	0	1[a]	1[a]	0	0	0	23[b]	96%
IgM (IFA)	11	5	3	4	1	0	0	32%

[a]negative for *T gondii* antibodies by latex agglutination test (LAT).

[b]positive for *T gondii* antibodies by LAT.

Discussion

The majority of parasites detected in this study have been reported previously in surveys of feral cats in Australia, though at differing prevalence. The relatively high prevalence of *T cati* and *A abstrusus* in the Christmas Island cats indicates the regular predation of rodents and/or birds, which can act as intermediate or paratenic hosts.[21] The diet of feral cats on Christmas Island is dominated by birds, flying foxes and introduced rodents.[16] *Toxocara cati*, the cat round worm, has been reported as occurring in feral cats throughout Australia, at varying prevalence.[8–15] The role of intermediate hosts, such as rodents and invertebrates, in the life cycle of *T cati* and of *Aelurostrongylus abstrusus*, and in the diet of feral cats, has been identified as a reason for the common occurrence of these parasites.[8,11,13]

Three species of *Strongyloides* that infect cats are *S felis*, *S planiceps* and *S tumefaciens*.[21] Previous studies on cats in Townsville, Queensland, detected *S felis* infections at a prevalence of 56%[22] and 33.5%.[23] *Strongyloides* species have not been reported elsewhere in feral cats in Australia.

The capillarids *Eucoleus aerophilus* (syn *Capillaria aerophila*), the tracheal worm and *Pearsonema feliscati* (syn *Capillaria feliscati*), the bladder worm occur in cats in Australia.[8,9,24–28] In Tasmania, *E aerophilus* was detected in 16.1% of feral cats examined in one study[8] and 5% in another.[9] *E aerophilus* was detected in 3% of cats examined from New South Wales[25] and in 5.2% of cats from the Sydney metropolitan area.[24] In Brisbane, *P feliscati* was detected in 34%[26] and 31%[27] of cats examined, whilst a third study detected it in the urinary tract of 6% of cats examined.[29] Prevalence was much lower (1%) in cats in the Sydney area.[24,28] Given that the present study used faecal examination only, it could be assumed that the capillarids detected are most likely *E aerophilus*. However *Calodium hepaticum* (syn. *Capillaria hepatica*) occurs within the parenchyma of the liver of rodents and it is not uncommon to find the eggs of this species in cat faeces.[21] The predation of rodents by feral cats on Christmas Island, [16] coupled with the high density of cats in a small geographic area (135 km^2) may explain the relatively high capillarid prevalence (21.4%) observed.

Ancylostoma tubaeforme is widely considered to be the common hookworm of cats, though other species include *A braziliense*, *A ceylanicum*, *A caninum* and *Uncinaria stenocephala*.[21] In Australia, *A braziliense* and *A tubaeforme* have been isolated from cats in northern Queensland, Northern Territory and the north-west of Western Australia.[10,30–32] Studies from the Northern Territory and Queensland have shown that cats can also harbour *A caninum*, though its occurrence is uncommon.[10,29,31] A study from the Cocos (Keeling) Islands showed that 80% of feral and stray cats examined were infected with a single species of hookworm; *A braziliense* (PJ Adams unpublished). Based on these findings it is most likely that the Ancylostoma sp detected in the present study is *A braziliense*, however the 10% formalin used to preserve the faecal samples precluded the use of molecular techniques to confirm the species.

The spirurid nematodes require intermediate arthropod hosts to complete their life cycles, however it is more likely that cats would become infected with these parasites through the ingestion of reptilian or amphibian paratenic hosts.[21] *Physaloptera praeputialis* is the most commonly reported species in cats in most parts of the world.[21] It has been reported from feral cats in Victoria[33] and the Northern Territory, suggesting it is a common parasite of feral cats in central Australia.[10,34] *Pterygodermatites cahirensis* is the only species of this genus reported from cats, occurring in North Africa, the Middle East and India.[21] There are no previous reports of this species (or genus) from cats in Australia. Representative specimens of Physaloptera and *Pterygodermatites* worms recovered from cats in the present study have been deposited with the Western Australian Museum, accession numbers WAM-V7304 and WAM-V7305 respectively.

The occurrence of *Taenia taeniaeformis*, in two of 28 cats, in this study is markedly lower than that observed in previous studies of feral cats from Australian islands. It was detected in 63% of feral cats from Kangaroo Island[14] and in 42.9% of feral cats from King Island.[8] The low prevalence of *T taeniaeformis* detected in this study is most likely due to a lower sensitivity of faecal examination compared to intestinal content examination, as previously demonstrated for helminths.[14,24]

Cystoisospora felis and *C rivolta* are common protozoan parasites of cats worldwide, and are typically more prevalent in younger animals.[21,35] A low prevalence of *C felis* and *C rivolta* is commonly reported from feral cats, as these studies are most likely to examine adult or mature cats,[8,12] as in the current study.

The protozoan *Besnoitia wallacei* was detected in a single cat in the present study. There is limited information available regarding this organism, however it has been reported from a cat fed naturally infected rats in Tasmania.[36] This is only the second report of *B wallacei* in a cat in Australia. The abundance of rodents on Christmas Island and their role in the feral cat diet may explain the presence of this parasite.

Cryptosporidium and *Sarcocystis* were found in only one cat each. The *Cryptosporidium* oocysts detected were tentatively identified as *C muris* based on morphology and are therefore most likely an artefact of consumed prey (rodents). Cats are known to transmit at least 11 named species of *Sarcocystis* and commonly become infected through scavenging and predation of various mammal species.[21] The species of *Sarcocystis* detected in the present study was not identified.

The high prevalence of *T gondii* antibodies in cats on Christmas Island may be due either to vertical transmission, from dam to offspring, or the consumption of tissue cysts within infected prey species. The relative abundance of non-native rodents and their predation by the cats[16] would provide ample opportunity for *T gondii* to complete its life cycle. Its high seroprevalence could be related to the significantly greater density of cats than estimates derived in a variety of biomes on the mainland.[37] This would result in a greater facilitation of vertical or horizontal transmission of *T gondii*, and a higher level of environmental contamination with oocysts. A recent study also detected a high serological *T gondii* prevalence in feral cats (87% by indirect hemagglutination test; 89% by direct agglutination test) on Kangaroo Island in South Australia.[14] This was consistent with antibodies detected in sheep on the island, suggesting that the feral cat was responsible for its high prevalence in this species.

Results of this study confirm that feral cats from Christmas Island contain many of the helminth and protozoan parasites reported from feral cats elsewhere in Australia. This suggests that high density feral cat populations with ready access to highly fecund intermediate hosts (rodents), may pose a high risk of environmental contamination with *T gondii*, *T cati* and *Strongyloides* spp infective stages. As such, contact with cat faeces and soil in the vicinity of cat defecation points could present an infection risk to the island human population. Particular concern is for pregnant women and immunocompromised people, as infections with *T gondii*, *T cati* or *Strongyloides* spp under these conditions can potentially lead to serious medical complications. It is recommended that normal hygiene practices such as hand washing before eating or coming inside the house, and wearing gloves when gardening in this environment should be observed to minimise the risk of becoming infected.

Acknowledgements

The authors would like to thank R Hobbs for comments on the manuscript, with thanks also to J Wickenden, A Graham and A Yon for their assistance. We would also like to acknowledge the financial support provided by Christmas Island Phosphate for this study.

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