Government of **Western Australia**

INTERIM REPORT ON STAGE 2 OF THE 'CHRISTMAS ISLAND CAT AND BLACK RAT MANAGEMENT PLAN'

Prepared by

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REPORT OUTLINE

The purpose of this project was to implement Stage 2B of the 'Christmas Island Cat and Rat Management Plan' (Algar and Johnston 2010). Drafting the Management Plan was funded by the (then) Attorney Generals Department (now DRARDLG) in 2009/10. Following acceptance of the suggested revisions to the current local cat management laws (*Shire of Christmas Island Local Law for the Keeping and Control of Cats 2004*) under the Local Government Act 1995 (WA) (Ci) Stage 1 of the Management Plan which involved de-sexing, micro-chipping and registration of all domestic (owned) cats on the island was successfully completed in late 2010.

The primary aim of Stage 2 of the Plan was to remove all stray cats within the residential, commercial and light industrial zones of Christmas Island. This also included cats at the Immigration Detention Centre (IDC), both at North West Point (NWP) and Phosphate Hill precinct. Without implementation of Stage 2 a significant source of cats, particularly natal recruits, would be available to disperse into or reinvade territories vacated across the rest of the island (i.e. the national park and Unallocated Crown Land). Rat management was also incorporated into Stage 2. Stage 2 was required before an island wide control program (Stage 3) could be implemented. Stage 2 was divided into Stage 2(a) and (b):

<u>Stage 2(a)</u> - Occurred in May to June 2011 funded by Parks Australia which included a contract with the Western Australian Department of Environment and Conservation (WADEC).
<u>Stage 2(b)</u> — commenced implementation from 1 July 2011 and will be completed by the end of the 2011/12 financial year and forms the basis of the funding received from DRARDLG.

The scope of works over the Stage 2(b) period focused on: -

- continued removal of stray/feral cats in the residential, commercial and light industrial area that particularly focused on the landfill site;

- continued removal of stray/feral cats at the Red-tailed Tropicbird rookeries located at the Sifting Room and Rumah Tinggi along the Settlement shoreline as recommended by Beeton *et al*. (2010);
- Managing rats within the residential, commercial and light industrial area where they appear most abundant.

This interim report focuses on cat control and documents the activities in chronological order conducted over the period 01 July – 31 October 2011, also included is the second survey for domestic cats and subsequent veterinary program in May 2011 and commencement of the trapping program in June 2011. During the period June – mid October, the effort has primarily focussed on the removal of stray/feral cats. Cage trapping has been the primary control technique employed to remove these cats. A baiting program was also undertaken, during late September/early October, along the roadsides/tracks that surrounded the residential and light industrial area.

A program to collect data on black rat movement patterns, home range, dietary preferences and bait acceptability was also instigated to provide information essential to the implementation of an effective and cost efficient rat control strategy. During the course of this program 160 rats were destroyed, the information gained (see Appendices 2 and 3) will provide the basis for delivery of rat control programs within the residential, commercial and light industrial zones in 2012-on. Appendix 4 provides preliminary information on the diseases found in a sub-sample of the cats and rats collected during this program.

1 BACKGROUND

There is extensive evidence that the introduction of domestic cats (*Felis catus*), to both offshore and oceanic islands around the world can have deleterious impacts on endemic land vertebrates and breeding bird populations (see Ratcliffe *et al*. 2009; Bonnaud *et al*. 2010). Island faunas that have evolved for long periods in the absence of predators are particularly susceptible to cat predation (Dickman 1992). Christmas Island - a high biodiversity island - is no exception.

Four of the five mammal species that were present on the island at settlement in 1888 have since become extinct. The diurnal native Bulldog Rat (*Rattus nativitatus*), for example, was reportedly common at the time of settlement; while the nocturnal Maclear's Rat (*R. macleari*) was extremely abundant. The Christmas Island Shrew (*Crocidura attenuata trichura*) has not been seen since 1985 and is believed extinct and, most recently, the Christmas Island Pipistrelle (*Pipistrellus murrayi*) is thought to have become extinct in 2009 (L. Lumsden pers. comm. 2009). While several factors are likely to have contributed to the demise of these native animals including disease, habitat destruction (land clearing and natural catastrophes such as cyclones) and the proliferation of the exotic Yellow Crazy Ant (*Anoplolepsis gracilipes*), the introduction of exotic competitors and predators such as the Cat and Black Rat (*R. rattus*) are also crucial factors.

In addition, several extant Christmas Island species are listed as being species likely to be adversely affected by cats and/or rats. These include the endemic Christmas Island Emerald Dove (*Chalcophaps indica natalis*) (listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as endangered); the Red-tailed Tropicbird (*Phaethon rubricauda*) (an EPBC listed marine species); and Forest Skink (*Emoia nativitatis*) and Blue-tailed Skink (*Cryptoblepharus egeriae*) which are not yet listed under the EPBC Act as threatened but are rapidly declining and under threat of extinction.

This impact of cats in particular, and also rats on the biodiversity of Christmas Island was of significant concern to land management agencies and the broader community. As a consequence, a ‘Management Plan for Cats and Black Rats on Christmas Island’ (see Algar and Johnston 2010) was commissioned that would mitigate the environmental and social impacts of cats and black rats across all land tenures (shire-managed lands, Crown land including mine leases and Christmas Island National Park). A strategy was recommended that provided a staged approach to cat and black rat management and control leading to eradication of one or both target species. This document reports on the commencement of Stage 2, in particular Stage 2(b) (see above, Report Outline).

2 METHODOLOGY

2.1 Site Description

Christmas Island is located in the Indian Ocean (10° 25'S and 105° 40'E) approximately 2,800 km west of Darwin, 2,600 km north-west of Perth, and 360 km south of the Indonesian capital of Jakarta (see Figure 1). The island has an area of approximately 135 km^2 and was formed from an undersea volcano that rose to the surface and has since subsided and risen over geological time. The oceanic island is composed primarily of Tertiary limestone overlying volcanic andesite and basalt (Tidemann *et al*. 1994; Environment Australia 2002). The island rises steeply from the surrounding ocean and consists of a series of fringing limestone terraces, separated by rugged limestone cliffs and scree slopes, rising to an internal central plateau at about 200 m and extending to 360 m above sea level.

The location of work conducted during this current program was primarily confined to the north-east corner of the island within the residential, commercial and light industrial areas. However, trapping was also conducted within and surrounding the Immigration Detention Centre at North West Point.

Figure 1. Location of Christmas Island. Image reproduced from DEWHA website

Christmas Island has a typical tropical, equatorial climate with a wet and a dry season. The wet season is from December to April when the north-west monsoon blows and about 60% of the annual rainfall occurs. For the rest of the year south-east trade winds bring slightly lower temperatures and humidity, and much less rain. Although the seasons are distinct, south-easterly winds may occur in the wet season and some rain may fall in any month of the year. The mean annual rainfall (based on data collected during the past 25 years) is 2,154 mm. Most rain falls between November and May with February and March the wettest months, August, September and October are the driest months. The pattern of the average number of rain-days per month follows that of the average monthly rainfall, decreasing from 20 in March to nine in September–October. During the monsoon, heavy downpours lasting several days and periods of humid calm weather are punctuated by gusty north-westerly winds. From May to November, long dry periods with steady south-east trade winds and occasional showers predominate. In years of significant El Niño activity in the Pacific Ocean, rainfall on the island tends to be relatively low. Cyclones and cyclonic swells from the north-west sometimes affect the island during the wet season.

Mean daily temperatures are 23–28°C in March and April and 22–26°C in August and September (Bureau of Meteorology 2009). Temperature varies little from month to month. The mean daily maximum is 28°C in March–April and the mean daily minimum is 22°C in August–September. Humidity also varies little between months and usually ranges from 80–90%.

2.2 Domestic Cat Survey

The `Management Plan for Cats and Black Rats on Christmas Island' (Algar and Johnston 2010) proposed a strategy to eradicate cats entirely from the island as the de-sexed domestic population dies out. This was based on four actions: to register and de-sex all domestic cats; to destroy all non-domestic (i.e. stray and feral) cats; to establish a 'cat prohibited area' along the Settlement shoreline to include the Red-tailed Tropicbird rookeries; and, to prohibit the importation of new cats. Cat registration was an essential first stage to two of these outcomes as it would: (i) ensure the release rather than destruction of domestic cats during trapping campaigns for stray and feral cats and (ii) to ensure the de-sexing all of domestic cats, preventing potential natal recruitment into the domestic, stray and feral populations.

To ensure that all domestic cats were registered it was necessary to conduct a survey for domestic cats, across the entire residential area, before the commencement of the veterinary program. The survey process involved doorknocking at each permanent residence and questioning the adult inhabitants as to whether they had any domestic cats. All residences were surveyed and, as added insurance, neighbours were also asked whether domestic cats were present in adjoining houses. All surveyed people were informed of the risk of not declaring the presence of a domestic cat and it not being subsequently registered. The survey recorded the number of owned cats per household, the sex, age, coat colour and whether the animal had been de-sexed.

A total of 152 cats (72 females, 79 males) was recorded during the initial survey in October 2010 (Algar *et al*. 2011). A total of 17% (90 households) of all the permanent residential houses on Christmas Island (n= 526) owned one or more domestic cats. The majority of households (73%) of households owned only one cat, with three households owning more than four cats (n=5, 6, 8) (op cit.).

The veterinary program is described in detail in Algar *et al*. (2011). Sixteen cats (six females, 10 males,) of those identified in the survey were unwanted animals and were euthanized. A total of 136 were micro-chipped and 31 of these cats needed to be de-sexed (nine females, 22 males).

A second survey for domestic cats, across the entire residential area, was again conducted in May this year prior to the commencement of a further veterinary program. This additional veterinary program was required because four domestic cats were greater than five weeks pregnant and could not be de-sexed safely during the first veterinary program in October 2010. These animals were to be treated with a contraception injection following the birth of the kittens and spayed on a return visit by the veterinarian.

2.3 Veterinary Program

The protocols followed during the veterinary program in October 2010 (see Algar *et al*. 2011) were adopted again during this second veterinary program.

2.4 Trapping Program

The registration and de-sexing of domestic cats was the first stage of the management plan (Algar and Johnston 2010), with the second stage - the control of stray and feral cats in the residential, commercial and light industrial area – now able to proceed. The trapping program commenced at the beginning of June 2011 and continued through till mid October. Trap sites were selected based on local knowledge of areas frequented by stray/feral cats, as well as areas deemed to be attractive to the target species. Traps were strategically located within these sites, typically in areas likely to be food sources and thoroughfares.

The trapping program used cage traps rather than leg-hold traps to minimise the risk of injury to domestic cats. Leg-hold traps will be employed, in localized areas, during subsequent trapping programs. Cats were captured using Sheffield wire cage traps (60x20x20 cm) with treadle plates (Sheffield Wire Products, Welshpool Western Australia). These traps were operated over five-day periods. All traps were covered with a hessian sack to provide shelter and protection to the captured animals until they could be collected. The traps were usually baited with cooked chicken wings (occasionally with fresh mulies (pilchards)) which were treated with the insecticide Coopex to maintain the longevity of the bait by deterring insects from consuming or spoiling the bait. The baits were cable-tied to the back of the cage to reduce trap failures by increasing the time animals spent inside a cage, thus increasing the likelihood of activating the treadle mechanism. Baits were replaced as necessary.

Trapped feral cats were euthanized by an intercardial lethal injection (Lethabarb, Virbac Australia). All animals captured were sexed, weighed and a broad estimation of age (as either kitten, juvenile or adult) was recorded according to their weight as a proxy for age. In addition, the pregnancy status of females was also used to determine whether the animal was an adult. The smallest weight recorded for a female that had recently given birth, at a time when sexually mature females had bred, was 2.0 kg and this was used as the minimum adult weight for female cats. The weight groupings for the cat age classes are provided in Table 1

Table 1. The weight groups for the cat age classes of the trapped population

Category	Male	Female
Kitten	< 1.0 kg	< 1.0 kg
Juvenile	1.0 – 2.4 kg	1.0 – 1.9 kg
Adult	2.5+ kg	2.0+ kg

A number of cats (and also rats) from the major capture sites (see Table 3, Section 3.3) were retained for analysis of stomach contents (see Appendix 3) and also the incidence of disease (see Appendix 4). Following euthanasia these animals were stored frozen until analyses were conducted. Hair and ear notches were also collected for future DNA analysis.

2.5 Baits and Baiting Program

The feral cat baits (*Eradicat*®) used were manufactured at DEC's Bait Manufacturing Facility at Harvey, Western Australia. Non-toxic baits were transported to Christmas Island and then kept in frozen storage. The bait is similar to a chipolata sausage in appearance, approximately 25 g wet-weight, dried to 15 g, blanched and then frozen. This bait is composed of 70% kangaroo meat mince, 20% chicken fat and 10% digest and flavour enhancers (Patent No. AU 781829) (see detailed description in Algar and Burrows 2004; Algar *et al*. 2007). Toxic feral cat baits are dosed at 4.5 mg of sodium monofluoroacetate (compound 1080) per bait. Prior to bait application, feral cat baits are thawed and placed in direct sunlight on-site. This process, termed 'sweating', causes the oils and lipid-soluble digest material to exude from the surface of the bait. All feral cat baits are sprayed, during the sweating process, with an ant deterrent compound (Coopex®) at a concentration of 12.5 g l-1 as per the manufacturer's instructions. This process is aimed at preventing bait degradation by ant attack and enhancing acceptance of baits by cats by limiting the physical presence of ants on and around the bait medium.

Previous research on Christmas Island has shown that terrestrial non-target species on the island, such as Robber Crabs (*Birgus latro*), Black Rats and feral Chickens (*Gallus*

gallus domesticus*), would have monopolised the baits if they were laid on the ground, greatly reducing the number of baits available to feral cats (Algar and Brazell 2008). These authors demonstrated a device (gantry) to suspend baits above the ground that effectively stopped bait removal by non-target species yet provided ready access to feral cats (Figure 2).

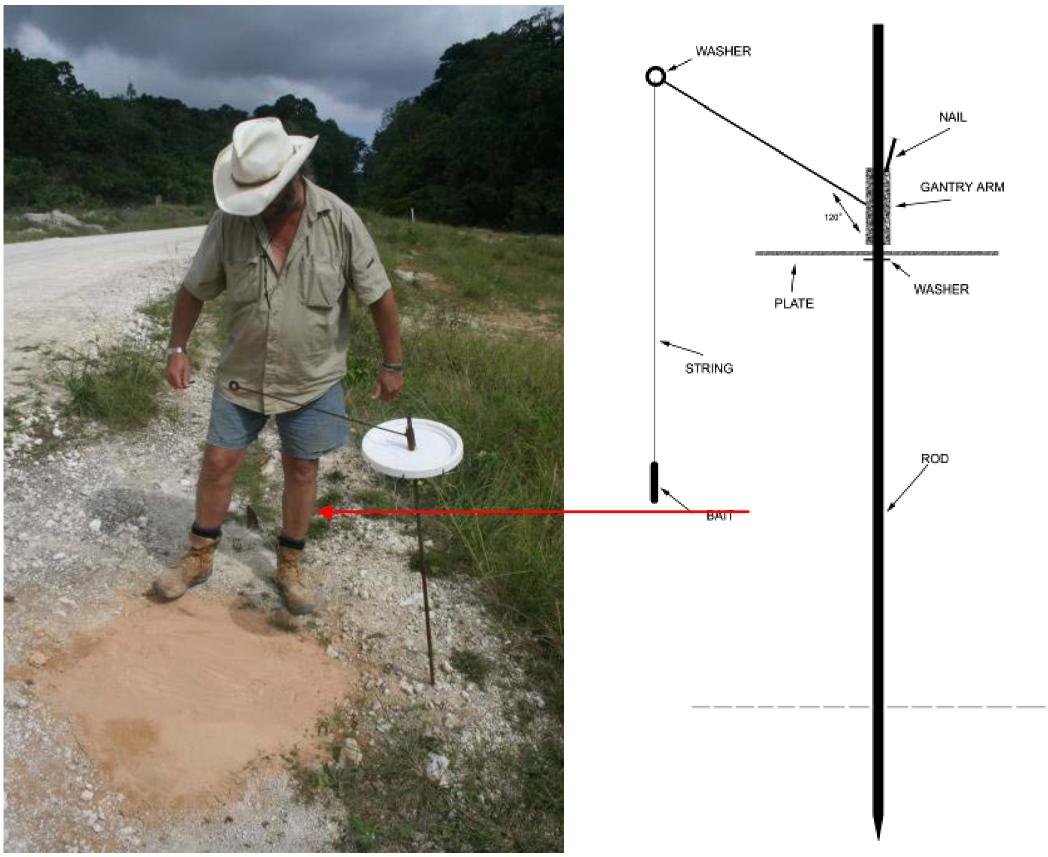

Figure 2. Bait suspension device. Schematic diagram reproduced from Algar and Brazell (2008)

A network of these 'Bait Suspension Devices' (BSDs) was established along approximately 18 km of roadsides/tracks that surrounded the residential and light industrial area. BSDs were located at 100 m intervals on both sides of the road/track, staggered at 50 m intervals across the road/track (Figure 3). A bait, comprising two *Eradicat*® sausages tied at the link, were suspended at a height of about 400 mm from each BSD using 6–8 lb fishing line. Unlike previous programs where a 1 m^2 'sand pad' of crushed phosphate dust was created underneath each BSD to enable the identification of species visiting the site, only BSDs one side of the road/track had sand pads.

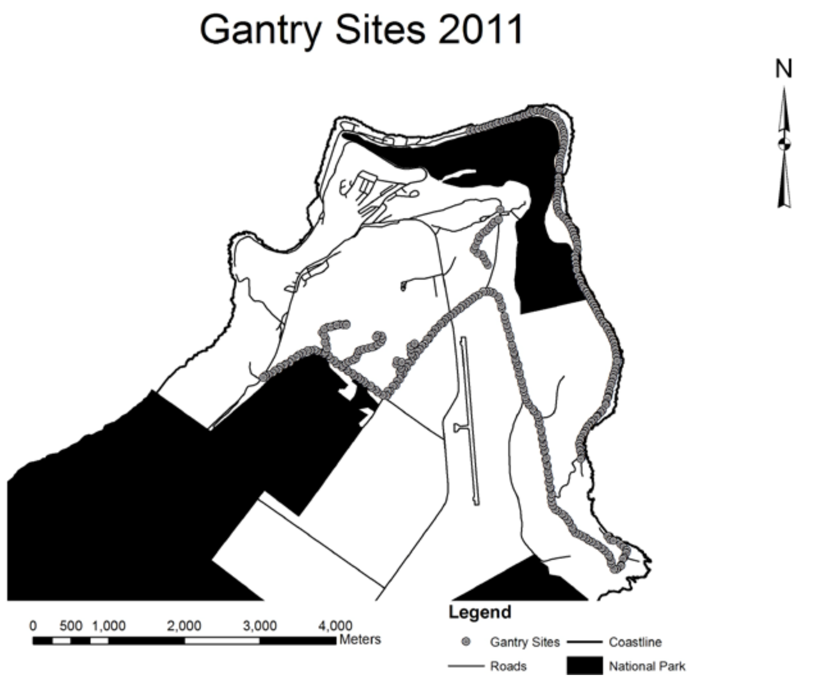

Figure 3. Network of Bait Suspension Devices surrounding the residential and light industrial area. Figure produced by D. Maple (CINP)

All BSDs were inspected daily over the 20-day baiting period to assess whether baits had been removed. To minimise the amount of toxic baits used, all BSDs were fitted initially with non-toxic baits until a bait had been removed. Baits at this BSD were then replaced with toxic baits containing 4.5 mg of 1080.

Bait removal from the BSDs was used to determine the efficacy of the baiting program. It was expected that a non-toxic bait would be taken by a cat, which would then subsequently return and remove a toxic bait. Replacement baits would continue to be provided until all the cats present in the area had eaten a toxic bait and died. Baits were also routinely replaced each week because phosphate dust raised by passing vehicles adhered to the baits and was considered likely to reduce palatability.

As bait station activity could not be ascribed to individual feral cats, a value for the maximum and minimum number of cats poisoned was determined. The total number of toxic baits removed was considered to indicate the maximum number of individuals poisoned. The minimum number of individuals poisoned was calculated by ascribing bait removals from consecutive BSDs to the same animal, even if ten or more stations were involved. The actual number of feral cats poisoned during this program would be between these two extremes. It was considered likely that some cats would visit multiple BSDs given the delay between bait consumption and onset of symptoms.

3 RESULTS

3.1 Domestic Cat Survey

The survey for domestic cats conducted this year revealed that of the 136 registered domestic cats 14 (six females, eight males) had died between the two survey periods. These animals had either died from natural causes, road fatalities or destroyed as the owners had moved off island.

3.2 Veterinary Program

Unfortunately, two of the four pregnant cats that could not be de-sexed safely during the first veterinary program in October 2010 were not administered with a contraception injection following the birth of the kittens and a second litter of kittens was produced by both cats prior to the second veterinary program. The kittens of one cat treated with contraceptive were destroyed at birth; the other 18 kittens/juveniles still alive were located. Of these animals, three kittens were euthanized; the other 15, along with the four she cats were de-sexed and registered. One female cat registered the previous year `was euthanized following a request by the owner. Two other cats, one of which had been de-sexed some years previously, were considered domestic pets and registered. Thus at the completion of the veterinary program in May this year there were 138 registered domestic cats (68 females, 70 males).

3.3 Trapping Program

A total of 5,121 trap-nights were conducted across the residential, commercial and light industrial area. The general location of trap points, trap numbers and dates of commissioning and decommissioning are presented in Appendix 1. The trapping program resulted in the removal of 194 stray/feral cats (122 females, 72 males), a biomass of 458.5 kg. The age classes of the trapped population are provided in Table 2 and the location of captures in Table 3.

Table 2. The age classes of the trapped population

Category	Male	Female
Kitten	9	25
Juvenile	18	23
Adult	45	74

Table 3. The location of captures and number of cats removed

Location	Number
Tip + Rec. Centre + IDC (Phosphate Hill)	66
Drumsite	48
IDC (North West Point)	15
Poon Saan + Silvercity	28
Kampong + Club Rd. + Flying Fish Cove	22
Settlement	11
Casino	4

Of the 74 adult females destroyed, 44 (59%) were pregnant, 12 (16%) were lactating, 16 (22%) were non-pregnant/non-lactating and 2 (3%) had been de-sexed.

While conducting the trapping program, 20 registered cats were trapped and returned to their owners, five of these animals were captured twice and one animal three times.

3.4 Baiting Program

Bait removal was recorded at 110 of the 365 BSDs (30%) over the 20-day baiting period. Of these, baits were removed at 44 BSDs on more than one night (40%) — sometimes several times over the baiting period — while baits were removed at 66 BSDs on one night only (60%). A total of 164 baits was removed by feral cats over this period, of which 49 (30%) were toxic (Figure 4).

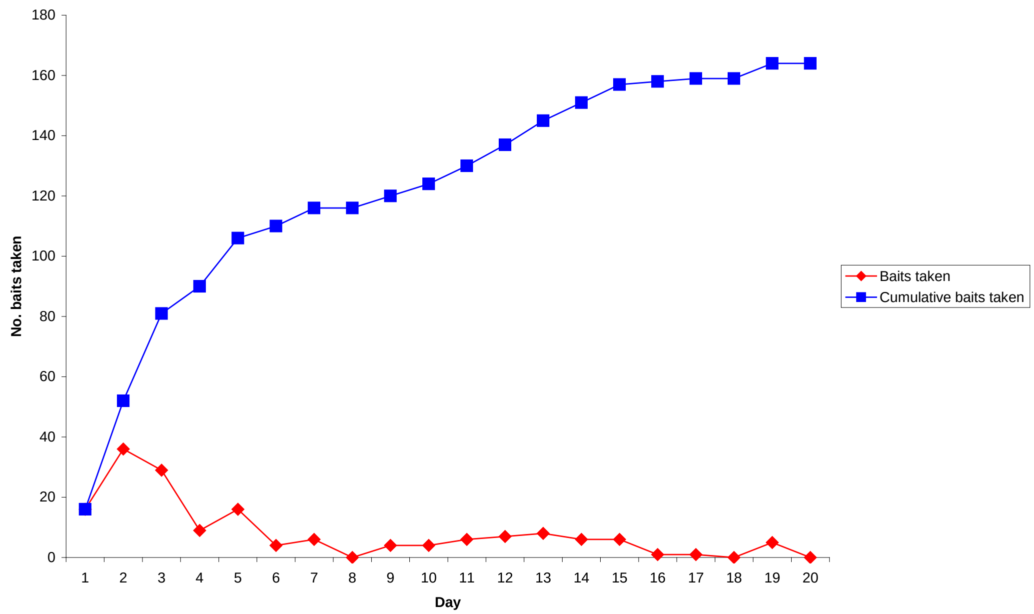

Figure 4. Number of baits removed from BSDs by feral cats

The total number of toxic baits removed, and by inference the maximum number of individual feral cats poisoned, was 49. The minimum number of cats poisoned was 36 (Figure 5), allowing for individual cats that may have consumed baits from multiple BSDs.

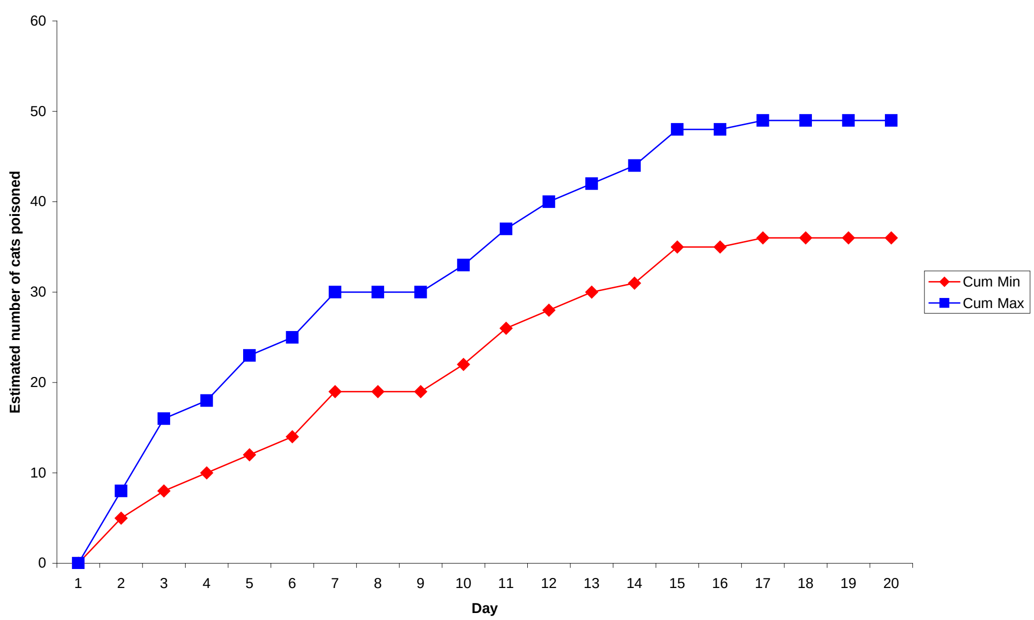

Figure 5. Estimated cumulative minimum and maximum number of feral cats poisoned following consumption of toxic *Eradicat* bait(s)

There were 28 occurrences when consecutive baits were removed from adjoining BSDs on the same day (data for major roads only, not the narrower tracks). On 13 of these occasions bait removal occurred on both sides of the road and on 15 occasions, bait removal was restricted to one side of the road only.

4 DISCUSSION AND RECOMMENDATIONS

De-sexing and micro-chipping of all domestic cats was completed in May this year and resulted in 138 owned cats being registered within the residential area of Christmas Island. The survey for domestic cats conducted this May suggested that the model of domestic cat decrease over time, based on an average lifespan of 15 years, was underestimated. The model indicated that domestic cats would no longer present on Christmas Island by 2024 (Algar *et al*. 2011) however, the attrition rate is higher than predicted, particularly because of road fatalities, and the island is likely to be free of domestic cats much earlier.

The substantial cat control effort conducted in the residential, commercial and light industrial area this year, primarily through cage trapping and to a lesser extent with baiting around the periphery, has removed over 200 stray/feral cats from the area. This successful campaign has led to the majority of stray/feral cats being destroyed within this zone. This will now enable the adoption of a more targeted approach, particularly through the use of leg-hold traps, to remove the remaining stray/feral cats. The strategic focus on individual cats and/or key areas within this zone will commence in May 2012 and will be reported in the subsequent final report.

Removal of these cats has been noticed by much of the community who have commented on the success of the campaign and appreciated the decline in stray/feral cat numbers. The return of captured domestic cats when captured and discussion of the program with the owners has also received a positive response. Both these factors have resulted in the community at large having an optimistic and constructive outlook on the program.

The nesting success rate of Red-tailed Tropicbirds along the Settlement shoreline this year is suggestive that the benefits of cat removal are already being observed. For the first time in a number of years there has been a dramatic increase in the survival of Red-tailed Tropicbird chicks. On Christmas Island, both domestic cats (identifiable by collars) and stray/feral cats have been photographed predating Red-tailed Tropicbird chicks. The euthanasia of a number of unwanted pet cats from residences along the Settlement shoreline in October 2010 and removal of a number of stray/feral cats from the same area prior to the nesting season is likely responsible, at least in part, for the improvement in the status of this iconic species (Algar *et al*. in prep).

The baiting program has once again demonstrated that control of the feral cat population on Christmas Island would be practicable using baits delivered on BSDs. The baiting program along 18 km of roadside/track removed between 36-49 cats over the 20-day baiting period. Ninety percent of these animals had been removed within two weeks and thus the length of baiting period could be reduced. The provision of non-toxic baits at each BSD, prior to uptake by cats, was undertaken to reduce the number of toxic baits used. At 66 BSDs removal of a toxic bait was not recorded following the take of non-toxic baits by feral cats. A temporal change in cat activity at certain bait stations may have been due to the general pattern of home range usage. In future, it is proposed that only toxic baits are used which would overcome this problem and also result in a more effective and rapid reduction of the cat population.

Previous observations of feral cat locations and general movements on the island, particularly on the major haul roads, suggested that in a number of instances cats repeatedly did not venture across the road where they were sighted but rather patrolled along its edge (Algar pers. obs.). Land features are often used to mark territory/home range boundaries and it was thought that this may be the case for cats with roads on Christmas Island. It was therefore decided to locate BSDs along both sides of roads to increase the likelihood of bait encounter. The results of bait removal from BSDs located on both sides of the road, confirmed the value of this deployment. In more then half of the occurrences when consecutive baits were removed from adjoining BSDs on the same day bait removal was restricted to one side of the road only. Location of BSDs on both sides of wider roads will now be adopted if future baiting campaigns.

This successful program is to continue in 2012 with additional targeted trapping and baiting programs to further reduce stray/feral cat numbers. A Black Rat control program is also to be implemented which is based on the findings from work conducted over the past six months.

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6 APPENDICES

6.1 Appendix 1 The general location of trap points, trap numbers and dates of commissioning and decommissioning

Location	Commissioned	Decommissioned	Trap Numbers	Trap Nights
Tip	30/05/2011	3/06/2011	50	250
Rec Centre	2/06/2011	3/06/2011	5	10
Tip	6/06/2011	10/06/2011	50	250
Rec Centre + IDC (Phosphate Hill)	6/06/2011	10/06/2011	22	110
Tracks Tavern including Jalan Ketah Meram Hardpan	14/06/2011	18/06/2011	20	100
12 Jalan Ketah Meram	13/06/2011	17/06/2011	5	25
School Kindergarten/CIP	13/06/2011	17/06/2011	5	25
Power Station and ROM Rd	13/06/2011	17/06/2011	5	25
ROM	13/06/2011	17/06/2011	5	25
Crushers	13/06/2011	17/06/2011	5	25
Crushers Tip and School Pavilion	13/06/2011	17/06/2011	5	25
Tracks Tavern including Jalan Ketah Meram Hardpan	20/06/2011	24/06/2011	20	100
12 Jalan Ketah Meram	20/06/2011	24/06/2011	5	25
School northern Boundary	20/06/2011	24/06/2011	10	50
CIP Seatainers/Labs	20/06/2011	24/06/2011	5	25
Wet Bins/Kiats	20/06/2011	24/06/2011	5	25
Poon Saan Rd Temples	20/06/2011	24/06/2011	4	20
San Chye Loh Temple houses and DIAC Block 564	20/06/2011	24/06/2011	5	25
Old Technical School Rd	20/06/2011	24/06/2011	5	25
DIAC Block 566	20/06/2011	24/06/2011	5	25

outer perimeter IDC (North West Point)	27/06/2011	1/07/2011	18	90
Poon Saan Shops, Lodge and warehouses	27/06/2011	1/07/2011	12	60
Old Poon Saan Shops/sea containers	27/06/2011	1/07/2011	10	50
Jalan Perak DIAC Block 671	27/06/2011	1/07/2011	5	25
CIP Silos Track	27/06/2011	1/07/2011	5	25
DIAC Block 568	27/06/2011	1/07/2011	2	10
Tong Chee Rd	4/07/2011	8/07/2011	5	25
Club Rd	4/07/2011	8/07/2011	15	75
Port Authority	4/07/2011	8/07/2011	5	25
Tip	4/07/2011	8/07/2011	14	70
outer perimeter IDC (North West Point)	4/07/2011	8/07/2011	18	90
Rec Centre IRPC	11/07/2011	14/07/2011	20	80
Club Rd	11/07/2011	13/07/2011	4	12
Interior IDC (North West Point)	12/07/2011	14/07/2011	20	60
Tracks tavern	12/07/2011	14/07/2011	2	6
Kampong	18/07/2011	22/07/2011	20	100
Flying Fish Cove	18/07/2011	22/07/2011	15	75
Lower Gaze Rd.	19/07/2011	23/07/2011	22	110
Gaze Rd Barracks to Mango Tree (inland side)	25/07/2011	29/07/2011	35	175
Gaze Rd Barracks to Sitting Room (coast side)	25/07/2011	29/07/2011	22	110
DIAC 567	25/07/2011	29/07/2011	3	15
Behind Mango Tree along the coastal strip to Police Station	31/07/2011	5/07/2011	40	200
Casino Waste and old building	31/07/2011	5/07/2011	10	50
Arenga Close	31/07/2011	5/07/2011	10	50
Rec Centre + IDC (Phosphate Hill)	31/07/2011	5/07/2011	20	100
North West Point water tank (Bkt traps)	31/07/2011	5/07/2011	2	6

Trucking depot	31/07/2011	8/08/2011	1	8
DIAC 567 (Bkt trap)	31/07/2011	8/08/2011	1	8
Phosphate Hill (Bkt trap)	31/07/2011	8/08/2011	1	8
DIAC 568 (Bkt trap)	31/07/2011	8/08/2011	1	8
Gas Bottle Area	2/08/2011	5/08/2011	2	6
Casino building's	7/08/2011	12/08/2011	20	100
Ma Chor Nui Nui Temple	7/08/2011	12/08/2011	2	10
Gas Bottle Area	7/08/2011	12/08/2011	3	15
Boat shed ,Tai Jin house and up to treatment work centre	7/08/2011	12/08/2011	15	75
Drumsite/Tracks area	7/08/2011	10/08/2011	6	18
Poon Saan Lodge	7/08/2011	12/08/2011	2	10
Kampong	12/08/2011	18/08/2011	2	12
Tip	14/08/2011	19/08/2011	40	200
Boat shed ,Tai Jin house and up to treatment work centre	14/08/2011	19/08/2011	17	85
Bus Shed near School	17/08/2011	19/08/2011	2	4
Information Centre	14/08/2011	19/08/2011	5	25
Quarry Road	21/08/2011	26/08/2011	25	125
Mine Incline from Drumsite to Settlement	21/08/2011	26/08/2011	27	135
Settlement Shop	21/08/2011	26/08/2011	2	10
Plant Hill Road	28/08/2011	2/09/2011	14	80
Kung Way Lane	28/08/2011	2/09/2011	10	50
Pack Mack and Micks House areas	28/08/2011	2/09/2011	4	20
Casino Area	28/08/2011	2/09/2011	30	150
Silvercity House No 10	29/08/2011	2/09/2011	2	10

Territory Park	4/09/2011	9/09/2011	15	75
Technical College and Community Centre Poon Saan	4/09/2011	9/09/2011	5	25
Seaview Drive Behind Houses	4/09/2011	9/09/2011	6	30
Drumsite/Tracks/Water tank	4/09/2011	9/09/2011	10	50
DIAC 567	4/09/2011	9/09/2011	1	5
Shipping Container Area	4/09/2011	9/09/2011	13	65
Airport Area	4/09/2011	9/09/2011	6	30
Phosphate Hill Area	4/09/2011	9/09/2011	16	80
Retreat Lodge	4/09/2011	9/09/2011	1	5
Quarry Powerline rd	9/09/2011	16/09/2011	20	140
Phosphate Hill Powerline rd	9/09/2011	16/09/2011	20	140
Cross Country	11/09/2011	16/09/2011	10	50
DIAC 670-674	18/09/2011	23/09/2011	10	50
Interior IDC (North West Point)	18/09/2011	23/09/2011	28	140
School	25/09/2011	30/09/2011	3	15
Pizza shop area	25/09/2011	30/09/2011	5	25
Flying Fish Cove	4/10/2011	9/10/2011	20	100
School	4/10/2011	9/10/2011	3	15
Poon Saan Shops	11/10/2011	16/10/2011	5	25
Total Trap Night				**5121**

6.2 Appendix 2. A summary of preliminary results and recommendations from an investigation into Black Rat foraging home range size, population density and spatial organisation (B. Low)

Home Range Size and Population Density

A total of 33 Black Rats were fitted with radio-collars, with 20 individuals collected from the Red-tailed Tropicbird colonies and 13 from urban areas. Additionally, three individuals that had been fitted with radio-collars were recaptured during the same trapping session, two from the Red-tailed Tropicbird colonies and one from urban areas. The average population density of Black Rats around the Red-tailed Tropicbird colonies was 24.6 rats/ha. This was higher than population densities in the urban areas, which averaged 10.9 rats/ha.

Radio-tracking resulted in a total of 324 location fixes, one shed collar, two dead animals and one missing collar. With the addition of trap sites, the number of locations for each rat ranged between 19 and 24. Home range and core size areas were calculated using both Minimum Convex Polygon (MCP) and Kernel Density Estimate (KDE) methods. The mean foraging home range size (95% of fixes) of male Black Rats was 0.542 ± 0.123 ha (MCP) and 0.893 ± 0.196 ha (KDE) in Red-tailed Tropicbird colonies, while in urban areas their mean foraging home range size was 0.568 ± 0.273 ha (MCP) and 1.055 ± 0.120 ha (KDE). This was significantly larger than the foraging home range sizes of female Black Rats across both habitats ($P < 0.05$), which averaged 0.381 ± 0.06 ha (MCP) and 0.676 ± 0.115 ha (KDE) in Red-tailed Tropicbird colonies and 0.175 ± 0.054 ha (MCP) and 0.272 ± 0.085 ha (KDE) in urban areas.

The mean core home range size (50% of fixes) of male Black Rats was 0.057 ± 0.015 ha (MCP) and 0.260 ± 0.051 ha (KDE) in Red-tailed Tropicbird colonies, while in urban areas their core home range size averaged 0.069 ± 0.007 ha (MCP) and 0.324 ± 0.022 ha (KDE). This was significantly larger than the core home range size of female rats, which averaged 0.058 ± 0.007 ha (MCP) and 0.223 ± 0.028 ha (KDE) in Red-tailed Tropicbird colonies and 0.030 ± 0.008 ha (MCP) and 0.090 ± 0.028 ha (KDE) in urban areas. There was also a significant interaction between habitat and sex when using the KDE method to estimate core home range sizes ($P < 0.05$). Further analysis highlighted that while there was no significant difference between the core home range size of male and female Black Rats around Red-tailed Tropicbird colonies, there was a significant difference between the core home range sizes of male and female Black Rats in urban areas. Additionally, the core home range size of male rats increased during the transition from coastal Red-tailed Tropicbird colonies to urban areas further inland. At the same time, the core home range size of female rats decreased during this transition.

Spatial Organization

Substantial overlap in home range both within and between sexes was observed at all study sites. The home ranges of all collared male rats in the Red-tailed Tropicbird colonies showed large amounts of overlap both with other males and with females. A similar pattern was observed in male rats in urban areas. Radio-tracked females generally maintained exclusive home ranges, with the exception of two females in the tropicbird colonies. However, analysis of trap data indicates that four radio-collared females across both habitat types shared their home ranges with the trap locations of at least one other non-collared female.

Management Implications

The density of Black Rats in these habitats has important management implications for controlling their populations. Results from this work suggest that an intensive baiting regime will be required to control coastal rat populations. Based on our home range analysis, a minimum of one bait station every 0.5 ha is required to account for the high Black Rats densities in this habitat. Ideally, bait stations should be placed in a 50 m by 50 m grid layout to increase the likelihood of individual rats encountering at least one bait station during their nightly forays. Bait stations around the seabird colonies will likely require significant resource input both in terms of labour and bait due to the high numbers of rats that are likely to visit these stations.

In contrast, baiting regimes in urban areas can be focused around areas of significant plant food availability such as fruit orchards as opposed to a blanket regime covering the entire urban settlement. This is because results of home range analysis indicate that female home range size decreased significantly in urban areas compared to seabird colonies. Furthermore, analysis of trapping data and personal observations indicate that female rats were clustered around chicken coops and urban gardens with high densities of fruit trees. Bait station placement should be concentrated around the aforementioned areas as they would not only control female rats using these areas as breeding sites but also provide a cost-effective way to control roving male rats, who have larger home ranges in urban areas but regularly wander into the core home ranges of neighbouring females, thereby increasing the likelihood that they will encounter these bait stations during their breeding forays.

6.3 Appendix 3. A summary of preliminary results and recommendations from an investigation into the diet of stray/feral cats (*Felis catus*) and Black Rats (*Rattus rattus*) to determine predatory impact and identify bait preference for use in a rat control program (G. Hayes).

Dietary Analysis- Cats

A total of 33 stray/feral cat digestive tracts and 51 black rat digestive tracts were analysed for the dietary study. Overall, the most frequently occurring food items in the diet of the stray/feral cats were plant matter (mostly grass) and invertebrates, which were consumed by 72.7% and 63.6% of cats respectively (Figure 1). These invertebrates consisted of grasshoppers and butterflies, which were unable to be more accurately identified, as well as giant centipedes (*Scolapendra morsitans*). The frequency of occurrence of the six food categories (plant, invertebrate, reptile, bird, mammal and scavenged) were significantly different ($P<0.001$). Plants (13.7 ± 3.5%), birds (12.4 ± 4.3%) and invertebrates (11.1 ± 2.9%) were the most abundant food items and all contributed similar quantities to the diet of the cats, accounting for approximately one third of the diet collectively (Figure 1). Similarly, the mean relative abundance of the six food categories were significantly different ($P=0.005$). Mammals were consumed by 27.3% of the cats and constituted 7.6 ± 3.1% of the diet (Figure 1). Scavenged material was consumed by 48.5% of the cats; however, it only accounted for 9.1 ± 2.5% of the diet (Figure 1). Mammals and birds that were consumed were identified as introduced species, namely Black Rats and feral chickens (*Gallus gallus*).

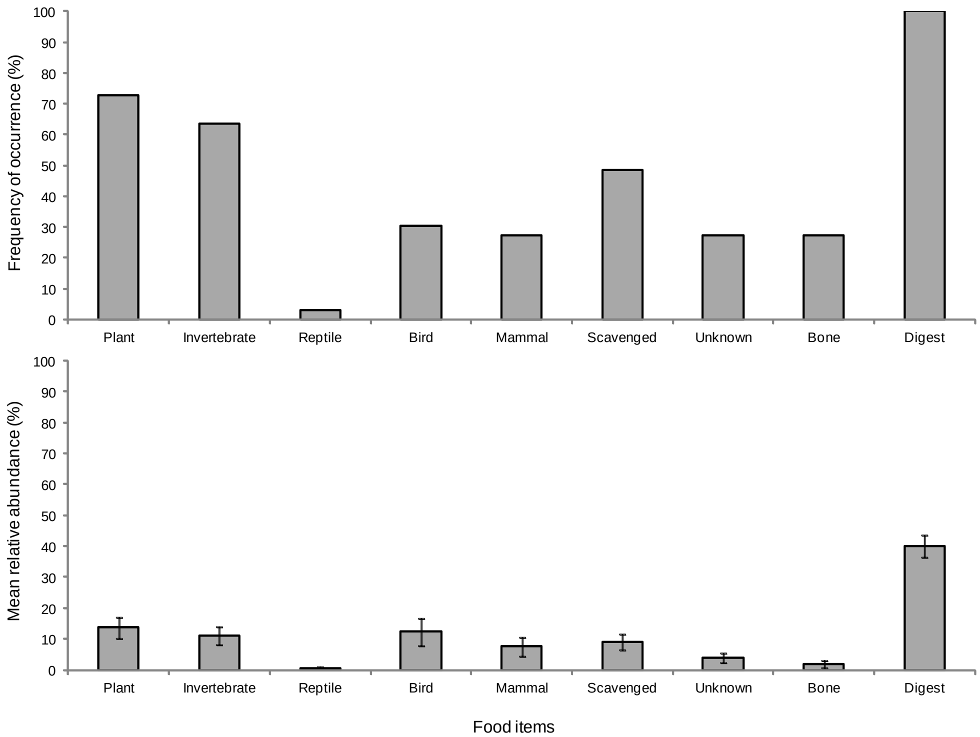

Figure 1. Frequency of occurrence (%) and mean relative abundance (%, standard error) of food items, not including bait, in the diet of stray/feral cats (*Felis catus*) on Christmas Island.

There was no statistical difference between the frequency of occurrence of the four broad categories of food items (plant, invertebrate, vertebrate and scavenged) in the diet of cats (*P*=0.130). While the difference was not significant, vertebrates and plants were the most frequently occurring food items and both were consumed by 72.7% of the cats (Figure 2). Similarly, there was no significant difference between the mean relative abundance of the four broad categories of food items (*P*=0.997). While the difference was not significant, vertebrates, accounting for 22.2 ± 4.7% of the diet, and plants, accounting for 13.6 ± 3.5% of the diet, were the most abundant food items (Figure 2).

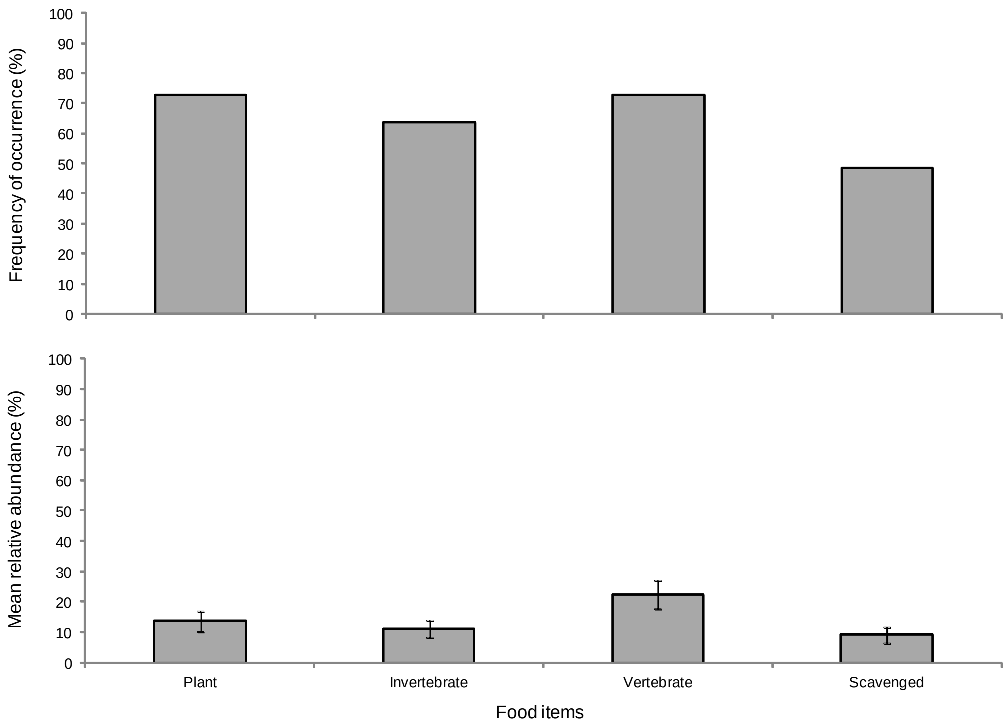

Figure 2. Frequency of occurrence (%) and mean relative abundance (%, standard error) of broad food categories in the diet of stray/feral cats (*Felis catus*) on Christmas Island.

Vertebrates identified in the diet of the cats were almost solely introduced species, specifically Black Rats and feral chickens. A comparison of the mammal and bird categories showed stray/feral cats consumed similar abundances of Black Rats and feral chickens. Only one native species, a Giant Gecko, was identified in the stomach of one cat.

While they were the only mammals present in the diet of stray/feral cats examined in this study, relatively few Black Rats were consumed. This was unexpected, as previous studies had shown that cats preferentially predate on mammal species, particularly introduced rodents (Risbey *et al.* 1999; Medina and Garcia 2006; Bonnaud *et al.* 2007; Peck *et al*. 2008). Populations of introduced House Mice (*Mus musculus*) have been reported in the settlement; however, these appear to be small (Beeton *et al.* 2010). Mice were therefore not expected to constitute a large proportion of the diet of stray/feral cats and, in fact, were not detected in the dietary study. Based on the success of the trapping program, Black Rats were considered abundant in the settlement area, suggesting that they were readily available as prey for stray/feral cats in this location. One possible explanation for the relatively few rats consumed is the abundance of other food sources in the settlement, including invertebrates and feral chickens.

No native mammals were detected, supporting the expectation that they would not form a large proportion of the diet of stray/feral cats, given the declines and likely extinctions of these species. While the Christmas Island Shrew and Pipistrelle are both considered to be extinct, the Christmas Island Flying Fox, likely the only native mammal still persisting on the island, is currently declining and has a limited population near the settlement area (Beeton *et al.* 2010). The complete absence of flying foxes from the diet of stray/feral cats may be an indication of the extent of the recent declines of its population size, given that the most recent previous dietary study on the island identified flying foxes as a substantial part of the diet of feral cats (Tidemann *et al.* 1994). Alternatively, the absence of flying foxes in the diet of the cats may be related to the location of sampling, as past studies sampled a wider range of habitats than this study.

Native vertebrate species were rare in the diet of the stray/feral cats examined, with a single Giant Gecko representing this category. Furthermore, this was the only reptile, native or introduced, identified in the diet of the stray/feral cats. Christmas Island is home to five native species of reptiles, all of which are threatened by extinction and have faced large range contractions in recent years (Cogger 2006; Beeton *et al.* 2010; DSEWPC 2011). It is therefore not surprising that the diet of stray/feral cats did not include native reptile species, which are rare or locally extinct in the settlement, as they were unlikely to be encountered by the cats (Beeton *et al.* 2010). It is probable that the diet of feral cats in the national park contains a higher proportion of native reptiles, where reptile populations are larger (Beeton *et al.* 2010). Conversely, it is surprising that introduced reptile species, including the House Gecko (*Hemidactylus frenatus*) and Barking Gecko (*Gehyra mutilata*), were not included in the diet of stray/feral cats given their abundance around the settlement (Beeton *et al.* 2010).

Feral chickens were the only bird species that contributed to the diet of stray/feral cats. An Imperial Pigeon may have been present in the gut contents of one cat; however, this was unconfirmed. Nevertheless, the possible contribution of this individual to the overall diet of stray/feral cats was negligible. The absence of native bird species from the diet of cats is not consistent with past studies, which have identified cats as key predators of bird species, particularly breeding seabirds (Courchamp *et al.* 1999; Blackburn *et al.* 2004; Le Corre 2008; Peck *et al*. 2008; Bellingham *et al.* 2010; Smith *et al.* 2010). Several species of breeding seabirds, including Brown Boobies (*Sula leucogaster plotus*) and Red-tailed Tropicbirds (*Phaethon rubricauda westralis*), were commonly found nesting on the ground in areas around the settlement. Therefore, inclusion of some native birds in the diet of stray/feral cats was expected, given the abundance of these birds and their accessibility to cats. Moreover, mortalities of chicks were observed during the trapping program, with inspection of chick carcasses suggesting cat predation as the cause of death (Neil Hamilton 2011 pers. comm.).

Invertebrates formed a large proportion of the diet of the stray/feral cats examined. While it was predicted that invertebrates would be included in the diet, the high relative abundance and frequency of occurrence was unexpected. Previous studies have suggested that invertebrates are only incorporated at low abundances in the diet of cats (Medina and Garcia 2006; Peck *et al.* 2008). Some invertebrates are known to be nutritionally beneficial to predators; therefore, stray/feral cats on Christmas Island may be consuming invertebrates to supplement their diet (Mayntz *et al.* 2005). Conversely, the exclusion of crabs from the diet of stray/feral cats was unexpected, given the high abundance and diversity of these animals on Christmas Island. It has previously been shown that feral cats consume red crabs on the island (Tidemann *et al.* 1994). Therefore, the apparent absence of crabs from the diet of stray/feral cats may be related to the location of sampling, as fewer red crabs inhabit the settlement than other locations on the island.

Plant matter, chiefly in the form of grass, comprised a large proportion of the diet of stray/feral cats. The large quantity consumed by multiple individuals was contrary to what was predicted. As cats are a predominantly carnivorous species, plant matter was expected to be consumed incidentally or in small amounts to aid regurgitation of indigestible matter (Tidemann *et al.* 1994; Risbey *et al.* 1999). Previous studies have shown that various species consume grass to balance nutrients in their diet (Clark 1982). This possibly explains the relatively large quantities of grass in the diet of stray/feral cats on Christmas Island.

Dietary Analysis- Rats

Overall, the most frequently occurring food items in the diet of black rats were plants and scavenged material, which were consumed by 58.9% and 39.2% of rats respectively (Figure 3). There was a significant difference between the frequency of occurrence of the four food categories in the diet of Black Rats ($P<0.001$). Plants (29.2 ± 5.3%) and scavenged material (19.6 ± 4.6%) were also the most abundant food items in the diet of the rats, accounting for approximately half their diet (Figure 3). Similarly, there was a significant difference between the mean relative abundance of these food items ($P<0.001$). A single, small feather was identified in the digestive tract of one rat, while small amounts of invertebrate material were identified in the digestive tracts of three rats (Figure 3).

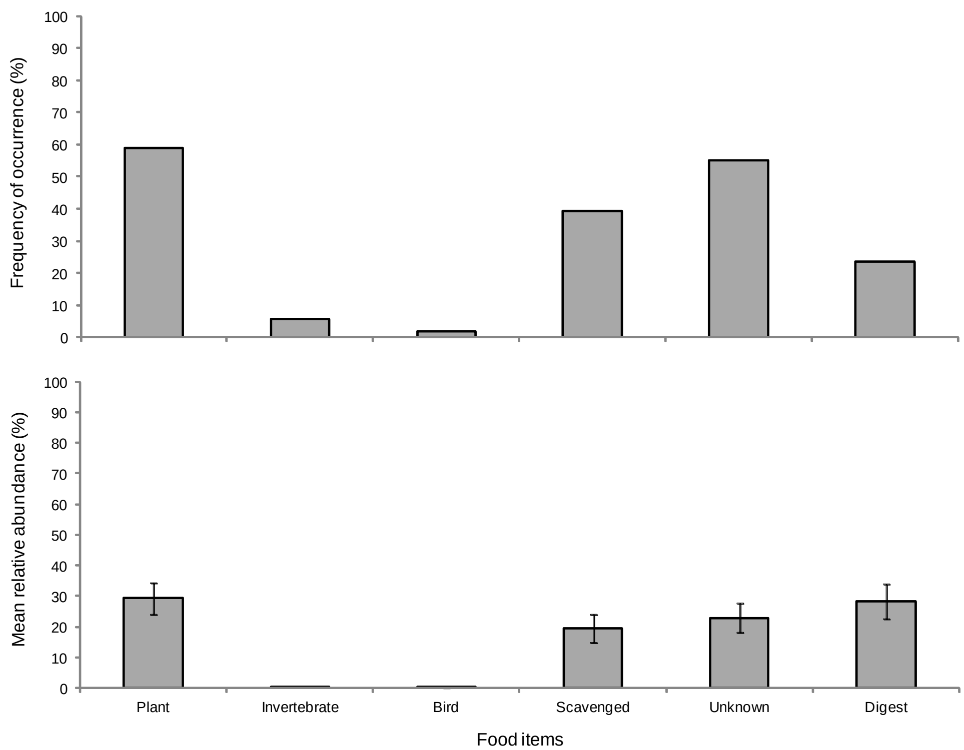

Figure 3. Frequency of occurrence (%) and mean relative abundance (%, standard error) of food items in the diet of Black Rats (*Rattus rattus*) on Christmas Island.

Plant matter comprised a large part of the diet of Black Rats. This finding supports previous studies on other oceanic islands that identified plant matter as the primary food source of Black Rats (Copson 1986; Harper 2007; Quillfeldt *et al.* 2008). This species is known to predominantly consume the food sources that are most readily available (Major *et al*. 2007; Caut *et al.* 2008). Therefore, the wide variety of fruiting plants abundant in and around the settlement at the time may have encouraged the large consumption of plants.

Invertebrate remains were identified at relatively low abundances in the digestive tracts of three rats. The presence of invertebrates in the diet was consistent with the findings of previous studies (Copson 1986; Cassaing *et al.* 2007; Harper 2007). However, a more frequent inclusion of this food item was predicted. Invertebrates may have been present in the diet of more Black Rats, but were not identifiable due to the highly digested nature of the contents. It is probable that, given three black rats consumed invertebrates, albeit at low abundances, they were also being consumed by other rats.

Bird remains were identified in the stomach contents of one Black Rat. It is probable that this consumption was incidental, given that only a single, small feather could be confidently classified as bird. However, it is possible that the feather was remnant of what had been consumed, with the rest being digested before the rat could be euthanised. No other vertebrates were identified in the diet of Black Rats. These results differ from other studies, which suggest that Black Rats supplement their diet with vertebrate and invertebrate species (Copson 1986; Harper 2007).

It was surprising that breeding seabirds were not included in the diet of Black Rats. Previous studies have identified Black Rats as predators of the eggs and chicks of breeding seabirds, with some reports of predation on adults (Courchamp *et al.* 1999; Caut *et al.* 2008; Le Corre 2008; Peck *et al.* 2008). This suggests that Black Rats on Christmas Island would also predate on breeding seabirds. However, given the abundance of eggs and chicks in and near the settlement, the absence of these species from the diet of Black Rats suggests that rats are not predating on seabirds on Christmas Island.

Native reptile species were not consumed by any of the Black Rats. This is consistent with the current status and distribution on the island of native reptile species. However, it was expected that introduced reptiles, common in the settlement area, would be included to some extent in the diet of Black Rats, as previous studies have shown that

Black Rats supplement their diet with reptile species (Caut *et al.* 2008; Beeton *et al.* 2010).

No mammals were identified in the diet of Black Rats. While other studies have identified Black Rats as occasional predators of mammal species, it was not surprising that Black Rats on Christmas Island were not predating on any mammals, given they are not a readily available food source on the island (Fellers 2000).

The rate of passage of food through the digestive tract of black rats has been shown to be rapid, with one publication suggesting that liquid passes through the stomach and small intestines in 204 minutes and solids in 258 minutes (Marcus and Lengemann 1962). In this project, with traps checked each morning, euthanasia of Black Rats could be delayed for up to 24 hours after capture, allowing ample time for digestion. Therefore, the lack of vertebrates and invertebrates in the diet of Black Rats, which was contrary to expectations, may have been a result of the rapid digestion rate of rats. However, if vertebrates and invertebrates were being consumed frequently, it is not likely that all identifiable material would be completely digested before the contents were analysed. Therefore, the lack of these food items in the diet of Black Rats is unlikely to be solely attributable to the rate of digestion.

Scavenged material was identified in the diet of both stray/feral cats and Black Rats. Since their environment was highly influenced by humans, it is not surprising that scavenged material constituted a significant part of their diet. Furthermore, both species have a number of biological traits that have promoted a generalist feeding strategy, allowing them to consume the food sources that are most readily available (Medina and Garcia 2006; Bonnaud *et al*. 2007; Peck *et al*. 2008). Therefore, the abundant supply and easy access to scavenged food undoubtedly encouraged its consumption, and may partly explain the lower than expected consumption of other food sources.

<u>Bait trial</u>

Using information collected in the dietary study, a baiting trial was designed for Black Rats. Racumin, a grain-based first generation anticoagulant poison, was selected as the trial bait. To determine the most palatable bait form, three different forms of this toxin were fed to the rats – cube, paste and paste soaked in coconut milk.

There was no significant difference in the net consumption of the Racumin bait by the two sexes of Black Rats (P=0.570). However, a significant difference was identified between the net consumption of the three bait types (P=0.007). The net consumption of paste soaked in coconut milk (12.87 ± 0.77 g) was significantly greater than the net consumption of the paste form (7.49 ± 1.12 g), while consumption of the cube form (9.15 ± 1.19 g) was not significantly different from either the paste or the paste soaked in coconut milk (Figure 4).

An outlier was identified in the paste trial. Removal of this outlier indicated that there was no significant difference in the net consumption of Racumin by the two sexes (P=0.579). Again, a significant difference was identified between the three bait types (P=0.011); however, without the outlier the net consumption of paste soaked in coconut milk was significantly greater than the net consumption of both the paste (8.52 ± 0.50 g) and cube forms (Figure 4). It was concluded that the findings were more representative when the outlier was excluded from the analyses.

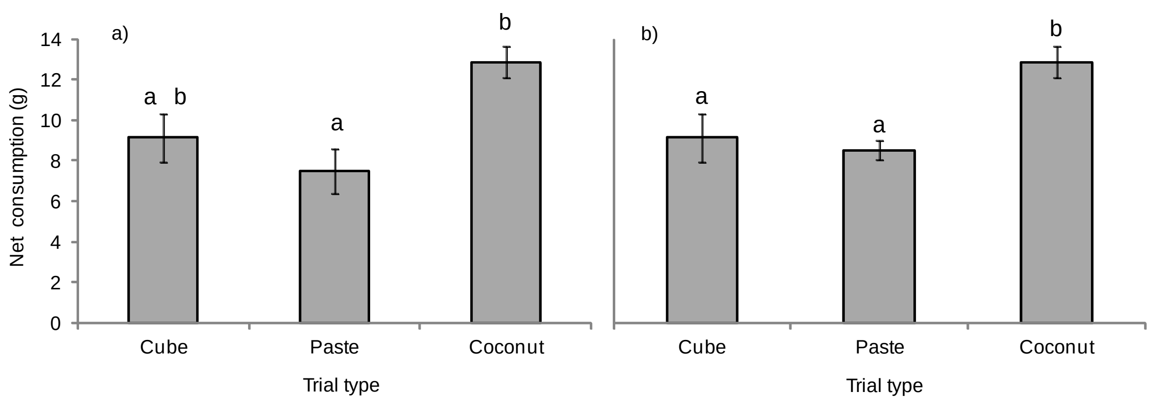

Figure 4. Mean net consumption (g, standard error) by Black Rats (*Rattus rattus*) of Racumin bait in the form of cube, paste and paste soaked in coconut milk. Means (and standard error) calculated (a) with an outlier and (b) without an outlier. Bars with different letters are significantly different.

Racumin in the form of paste soaked in coconut milk was the most palatable bait offered to the Black Rats. This confirms the findings of other studies that additives increase the consumption of bait by rodents (Bullard and Shumake 1977; Marsh 1988; Shafi *et al.* 1992). This knowledge will improve the chances of success of toxic baiting of Black Rats on Christmas Island, as well as other tropical islands. The paste, which was consumed in similar quantities to the cube, was selected to soak in coconut milk as it was easier to handle. As the results of this baiting trial will be immediately and directly applied to the Black Rat baiting program commencing in 2012, it was important to select the bait form that was both most palatable and easiest to distribute.

Racumin was selected for the bait trial as it is grain based. This was expected to appeal to Black Rats as they were predominantly consuming plant matter in their regular diet. This was particularly important as Racumin is a first generation anticoagulant, requiring multiple feedings by an individual on the toxic bait to achieve a lethal dose thus providing some protection to non-target species (Howald *et al.* 2007; Varnham 2010). It is assumed that using an additive, such as coconut milk, will increase palatability in the field and encourage multiple feedings by Black Rats.

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6.4 Appendix 4. A summary of preliminary results from an investigation into the incidence of disease in stray/feral cats and Black Rats (N. Dybing).

Full necropsies were conducted on stray/feral cats and black rats sourced from 21 trap locations for cats and 16 locations for rats on Christmas Island. Necropsies included an external examination for ectoparasites by combing their fur and upon close visible inspection and an internal search within organs, such as lungs, liver and bile duct, spleen, heart and trachea, for any macroscopic helminth parasites. If needed the organ was examined under the dissecting microscope for closer inspection and parasites extracted. Blood, serum (from fresh samples i.e. not frozen carcasses) and tissues samples including spleen, kidney, liver, brain, lymph nodes, diaphragm, cardiac muscle, lung and tongue were also taken for future analysis, including Polymerase Chain Reaction and DNA sequencing. Faecal samples were also collected to examine for protozoan parasites and parasite eggs. Faecal analysis, PCR and DNA sequencing will be conducted at a later date.

Necropsy results (i.e. organ search) and gastrointestinal results will be covered separately. This is due to some gastrointestinal tracts (GI) of cats still waiting for analysis and a full necropsy is yet to be performed on some black rats where the GI tract has formerly been searched. Following necropsy of 66 cats, 3% of cats had *Aelurostrongylus abstrusus* (lung parasites, Figure 1 and 2) and 11% harboured *Platynosomum concinnum* (bile duct flukes, Figure 3 and 4). *Platynosomum concinnum* is a trematode generally found in the tropics, including Malaysia, Hawaii and the Caribbean and has not be noted previously in Australia (Bowman *et al*. 2002). Of all 66 cats, only one was found to have any ectoparasites, a single flea yet to be identified to species. Necropsy of 48 black rats found *Angiostrongylus cantonensis* (lung parasites) and other unidentified lung parasites (2% and 6% respectively) and 21% harboured the strobilocerci stage of *Taenia taeniaeformis* in their liver. Forty five black rats harboured ectoparasites. Ectoparasites found included various species of mites, lice and fleas (identification to species is ongoing).

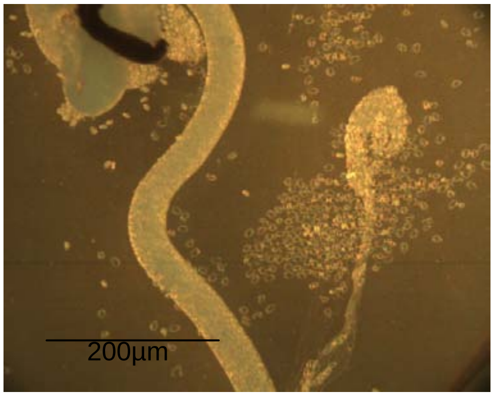

Figure 1. ***Aelurostrongylus abstrusus*** **from a cat lung**

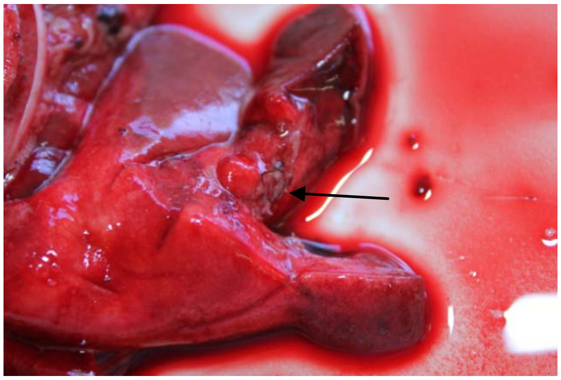

Figure 2. Cat lung with arrow showing *A. abstrusus*

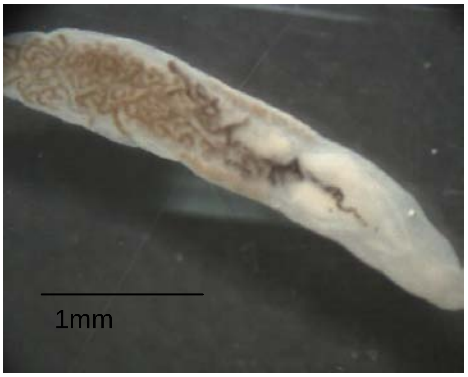

Figure 3. ***Platynosomum concinnu*****m from the bile duct of a cat.**

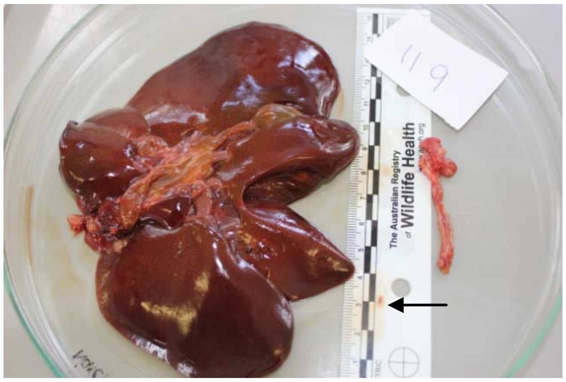

Figure 4. Liver of a cat showing dilate bile ducts indicating infection with *P. concinnum.* Arrow pointing to a specimen of *P. concinnum*.

The GI tracts of 31 cats and 59 black rats were examined under a dissecting microscope. Eighty seven percent of feral cats were found to accommodate gastrointestinal parasites. Five species of helminths were recovered from feral cats- two cestodes, two nematodes and at least one species of acanthocephalan. Parasites found include *Taenia taeniaeformis* (74%) (refer to Figure 5), *Dipylidium caninum* (29%), *Toxocara cati* (55%) (Figure 6), *Ancylostoma* spp (52%) and acanthocephalan spp (3%). Further identification to species of the acanthocephalan and *Ancylostoma* parasites is ongoing. One cat also harboured a parasite resembling a *Rictularia* species but further identification is needed to confirm this. This is the first report of this parasite within cats in Australia. There were also four cats that harboured, as yet, unidentified roundworms due to the specimens recovered not being whole.

Figure 5. Taenia taeniaeformis from a cat showing rostellum hooks and suckers

Figure 6. *Toxocara cati* from a single cat stomach

Six species of helminths were found in black rats - one cestode, three nematodes and two acanthocephalans. Seventy two percent of black rats, whose GI tract was examined, harboured parasites. Parasites included *Moniliformis moniliformis* (12%), *Rodentolepis nana* (3%) and *Syphacia muris* (22%). Further parasites were found but identification needs to be confirmed. Possible species include *Rictularia* spp (43%) (Figure 8), *Protospirura muris* (24%) and acanthocephalan spp (3%) (Figure 9). There were 10 rats that were found to harbour roundworms which require further efforts to identify due to poor specimen quality.

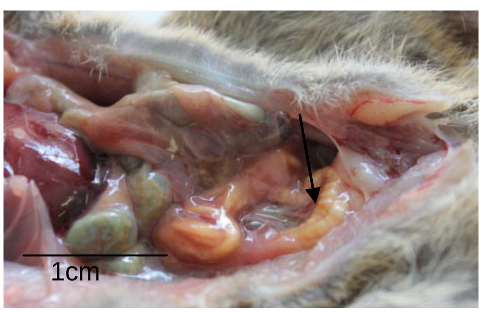

Figure 7. Moniliformis moniliformis within small intestine of a rat

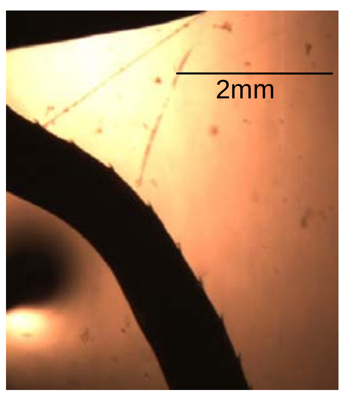

Figure 8. Possible *Rictularia* spp

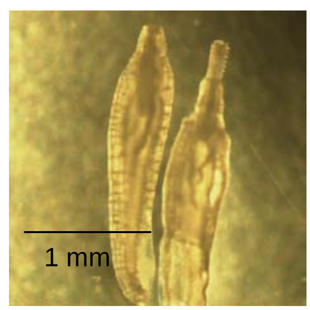

Figure 9. Acanthocephalan spp yet to be identified

Many of the parasites found within stray/feral cats and black rats have a zoonotic potential. Cats parasites *D. caninum, Ancylostoma* spp, *T. taeniaeformis* and *T. cati* have been previously reported in humans. Human infection usually arises from ingestion of the intermediate host of these parasites or from exposure to contaminated cat faeces in the environment (Robertson *et al*. 2000). Hookworm infections (i.e. from *Ancylostoma* spp) can cause severe anaemia in the normal definitive host but when humans are infected they can get a condition called creeping eruption which can cause dermatological issues (Bowman *et al*. 2010). *Toxocara cati* is a common human parasitic worm in the United States. After ingestion of eggs from cat faeces, the larvae migrate through internal organs causing a condition called visceral larval migrans, with an outcome of an antiinflammatory response in the host. This results in immunopathological damage to tissues (Hotez 2009). Human infection is also possible from *Platynosomum concinnum,* however this would require the ingestion of the intermediate host (a lizard) (Bowman *et al*. 2002).

From black rats the lung parasite, *A. cantonensis*, has been known to pose a threat to public health and can be fatal in humans. This parasite has known to cause neurological disease in a range of hosts from Australia including humans, flying foxes, dogs and many marsupials. Infection in animals is due to ingestion of an intermediate host which can be any native or exotic mollusc and infection is humans is due to either ingestion of raw or undercooked snails or other vectors, or from contaminated water and vegetables (Prociv 2001). Humans are a known definitive host for the cestode *R. nana*. This cestode is unusual in that it does not require an intermediate host in its life cycle. This parasite can be acquired by ingestion of the intermediate host or direct transmission resulting from ingestion of eggs voided in the faeces of the definitive host (Coleman 1968; Griffiths 1971). *Moniliformis moniliformis* and *Rictularia* spp are also potentially zoonotic (Waugh *et al*. 2006). For human infection both of these parasites require ingestion of the intermediate host.

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