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The ecology of feral cats (*Felis catus*) on a New Zealand offshore island: Considerations for management

A thesis presented in partial fulfilment of the requirements for the degree of

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Kathryn Emily Strang

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There is a predator within me
One that craves to stalk you
My neverending prey
For with you I have
The thrill of the hunt
In the night and in the jungle
Feel my roar vibrate through your bones
And know me to be a beast
Aggressively marking you as my territory
Claws that dig into your fur
Canines that linger in your warmth
And this is the beginning
Of our wild hunt

Abstract

Invasive species have contributed to the global biodiversity crisis, with the majority of recent-day terrestrial vertebrate extinctions implicating invasive predators. Domestic cats (*Felis catus*), particularly feral cats, are among the main culprits. In New Zealand, the continued decline of native species is largely due to invasive predators, which has led conservation efforts to focus on pest management. Feral cats are often a secondary focus for pest control, and their impacts within an ecosystem are not well understood. The main objective of this study was to produce a comprehensive study of feral cat ecology using a population of feral cats on Ponui Island, New Zealand, and highlight factors that should be considered for efficient control operations.

Predators distribute themselves and move within their environment in relation to prey availability and habitat type. These factors vary between locations, leading to differences in home range sizes that are difficult to predict. A relationship between home range size and population density was identified in the literature, which I used to predict changes in home range size with changing population density. I mapped the home ranges of eight cats for one year using location points from Very High Frequency (VHF) radio-telemetry and camera traps, then two males were removed from the population, seven months apart. The first removal resulted in an increase in the home range sizes of the remaining cats, whereas the second removal saw an invasion of four unmarked male cats. These results show that feral cats change their home ranges accordingly with changes in density, and removals (such as control operations) result in a change in feral cat ranging behaviour.

Feral cats are often live-trapped during control programmes to reduce capturing non-target animals. This technique is labour intensive because traps need to be checked frequently for welfare purposes. Describing feral cat activity patterns can dictate when live-traps should be set and checked. Camera traps have recently been used to estimate activity patterns, but have yet to be validated against accelerometry devices. Therefore, I compared the activity patterns obtained through camera trap data to that from collar-mounted accelerometry devices, and found a high correlation ($R^2 > 0.9$) between the two methods. The highest correlation was when activity from 600 or more videos was used. Feral cats were most active between sunset and sunrise, and live-traps should be set during these times to increase trapping efficiency and reduce bycatch.

The reproductive biology of invasive predators can be used to predict the recovery of populations following control operations, however there is very little information available for

feral cats. Therefore, I investigated the reproduction of feral cats in a stable, insular population. Using camera trap data, I found that females had high reproductive output, averaging three kittens per litter and two litters per year. However, the recruitment rate was low in this population; only 3-4% of kittens survived to one-year-old. There were two infanticide events observed; the first reported for solitary-living feral cats. Females moved shorter distances when they had young kittens (less than seven-weeks-old). These results show that feral cats can rapidly recover from control operations. Females are less likely to encounter traps when they have young kittens, suggesting there are optimal seasons to capture cats.

Population genetics is used in invasive biology to identify populations that are isolated and have limited immigration. Eradication of isolated populations will be easier and more cost-efficient, with low chances of reinvasion. Although offshore islands are geographically isolated, there is the chance of reinvasion that is assisted by humans. I investigated the population genetics of the feral cats on Ponui Island using genetic samples collected from adults and kittens, and also opportunistically studied parentage. Most of the fathers of the litters were the heaviest males, and the males that had the most home range overlap with queens. Population genetics showed that the cats have most likely been isolated with no recent introductions, suggesting the removal of cats from this island would be successful with low chances of reinvasion.

Feral cats can have large impacts on native species, but prey on rats that also have detrimental effects on wildlife. This led me to investigate the diet of feral cats using scat analysis on an island with native birdlife, and rodents at high densities. I examined season and sex differences on diet and the impacts of cats on native species. Feral cats consumed prey based on seasonal availability, with cats eating rats when rats were at their highest density. Females ate smaller prey more frequently than males, such as passerines. The cats on this island are not reliant on the rat population, and were found to eat many native species such as brown kiwi, morepork, and fantails.

The findings from this thesis can be applied to feral cat management to develop efficient control operations. The decision to control a population should be based on both dietary and genetic data to reduce possible cascading ecological effects from the predator removal and identify genetically isolated populations. Home range, activity, and diet data can be used to determine the control protocol, such as; trap spacing, the time traps should be set and checked, and if secondary or primary poisoning should be used and the seasons that cats would uptake the baits. Finally, knowledge of feral cat reproduction can be used to predict the recovery of the population.

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Days spent on Ponui from 2014-2018	375
No. of boat trips to Ponui	43
Kilometres driven between Palmerston North and Kawakawa Bay	42570 (559 hours)
Kilometres of transect walked	924
Sleepless nights trapping	24
No. of camera trap videos	174571
Hours of camera trap footage	1454 (60 days)
Hours spent sifting and IDing cat scats	325
PCRs run	2589
PCRs rerun (because the PCR gods failed me)	975
No. coffees drunk during PhD	~5200
No. muesli bars eaten in the field (they are a lifeline)	~774

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