Invasion Ecology and Genetics of Norway Rats on New Zealand Islands

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Biological Sciences and Statistics

by
James C. Russell
School of Biological Sciences
Department of Statistics
University of Auckland
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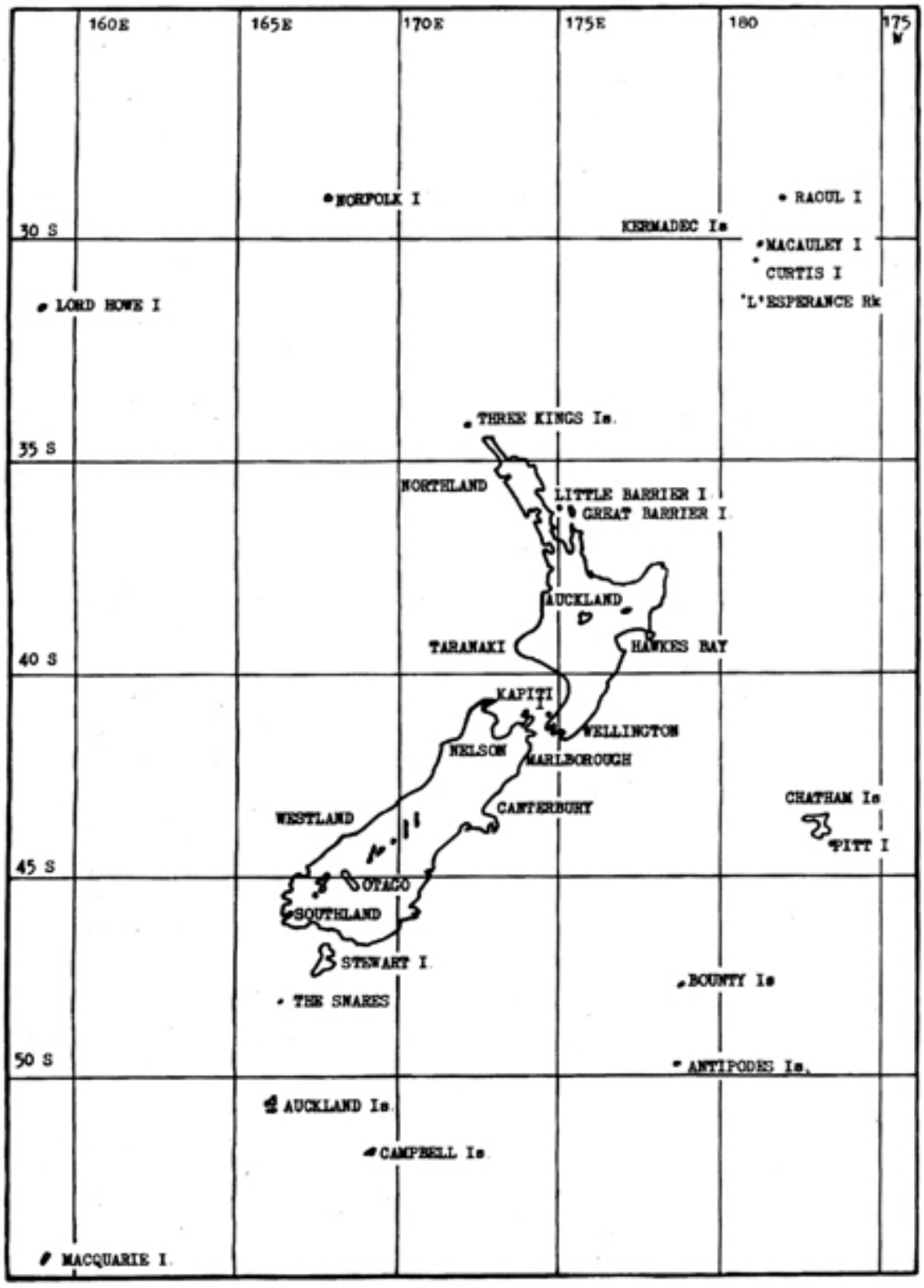

New Zealand and its outlying islands

Abstract

Introduced rats have invaded over 80% of the world's oceanic island groups, with devastating consequences for the endemic biota. Techniques developed in New Zealand allow rats to be eradicated from very large islands, enabling conservation of biodiversity. However even when rats have been eradicated, it is possible that they can reinvade islands. Current scientific and technological methods have failed markedly in preventing reinvasion.

It is unknown why difficulties in preventing reinvasion are encountered, but it has been postulated that this is due to a change in behaviour at low density that has management implications. Norway rats (*Rattus norvegicus*) are particularly adept island invaders, due to their propensity to swim, and so experimental releases of of adult male Norway rats on to small forested rat-free islands in northern New Zealand were used to study the behaviour of invading rats and assess management methods.

Currently management of islands to prevent reinvasion is undertaken without a standard framework or knowledge of the suitability of many control devices. Without testing devices under realistic field trials of single invading rats, it can not be guaranteed that they will successfully prevent reinvasion. Permanent island biosecurity systems performed better than contingency responses which evoked enhanced neophobia in invading rats. Invading rats were reluctant to interact with any artificial devices, particularly bait stations. An integrated approach using multiple devices including traps, poisons and trained rodent dogs was consistently the best approach to detect and eliminate invading rats, which can have high individual variability in behaviour.

When animals arrive in a novel environment their behaviour will change, with particular focus on spatial exploration in order to acquire a cognitive representation of their new environment. Rats usually remained around release sites for three days, changing den site often, before establishing a stable den site and exploring the entirety of small islands in the first week. Prevailing nightly ranges were between 0 – 5 hectares, with at least 35% of any given nightly range not having been visited the previous night. Nightly ranges were constrained by den sites,

which acted as central foraging locations. Invading rats could move over a kilometre in one night.

A recent island invasion was used to collect samples of an invading Norway rat population prior to its eradication. Studies of small populations with only a single opportunity to collect specimens result in sparse data. Population genetic methods provide additional information which can be used in investigating a population. The effective population size is one such population biology summary parameter, and data on linkage disequilbrium can be used from a single sample to estimate effective population size. Simulated populations were used to assess the precision and accuracy of the estimator relative to true demographic values. Recent trends in census population size, as well as the mating system and sample size relative to effective population size, all have substantial effects on the bias of the estimate.

It remains unclear how invasive species overcome bottlenecks from colonisation. Ecological and genetic methods were used to investigate a recently colonised small island population of Norway rats. Multiple genetic methods all detected a clear bottleneck signal, and parentage assignment revealed a promiscuous mating system. Norway rats are highly capable invaders of islands who have evolved life-history strategies allowing them to rapidly establish a large population,

Recommendations are finally made for island biosecurity to prevent rat invasion. These recommendations are based upon consideration of dispersal and invasion rates, and methods of detection and prevention. If island biosecurity is conducted regularly with proven tools, it should be possible to maintain large islands free of rats even when a high invasion rate is present.

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