EARLY DETECTION AND ERADICATION OF INVADING RATS

James C. Russell
University of Auckland, Auckland, New Zealand

Mick N. Clout
University of Auckland, Auckland, New Zealand

David R. Towns
Department of Conservation, Auckland, New Zealand

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JAMES C. RUSSELL AND MICK N. CLOUT, University of Auckland, Auckland, New Zealand
DAVID R. TOWNS, Department of Conservation, Auckland, New Zealand

Abstract: Invasive rats continue to colonize rat-free islands around the world. To prevent rats from establishing on rat-free islands, especially following their eradication, biosecurity actions are required to enable early detection and elimination. Rats arrive at islands by both human transportation and by swimming. There are very little data on the rates of rat transportation by humans, although it is known that they are not negligible. There are better data on the distances rats can swim, allowing estimates to be made of the risk of reinvasion of islands close to source populations. Biosecurity prioritization must take place across all rat-free islands, balancing the likelihood and impact of rat establishment. Dense grids of poison bait stations are not preferable for preventing rat invasion. Instead, surveillance systems that integrate multiple device types appear to be best for intercepting invading rats, but must be tested to ensure they are effective. This can be done by releasing a controlled number of monitored rats onto a rat-free island. Islands can now be maintained rat-free despite non-negligible reinvasion rates; however, in some cases islands must be managed within a larger meta-population context and eradication may never be achieved.

Key Words: biosecurity, detection, invasion, invasive species, islands, *Rattus*, risk, rodents.

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INTRODUCTION

Invasive species continue to colonize new locations, facilitating the homogenization of the world's biodiversity on a global scale (Collins et al. 2002). Islands are particularly vulnerable to the changes caused by non-native species (Courchamp et al. 2003). Invasions by non-native species should not be considered inevitable. Preventative measures (biosecurity) can be effective, especially when there are natural barriers to colonization. Biosecurity is most easily implemented on islands, where the natural water barrier acts as a filter the arrival of species, and arrivals are often focused at points of activity (e.g., ports/airstrips). Effective biosecurity that prevents invasion is economically more cost-effective than responding after an invasion has happened (Leung et al. 2002).

Three invasive rat species (*Rattus exulans*, *R. norvegicus* and *R. rattus*) have collectively colonized every continent except Antarctica, and over 80% of the world's oceanic island groups (Atkinson 1985). Invasive rats impact on human health, and agricultural, economical and conservation values (Singleton et al. 2003). Their negative impacts on insular ecosystems and species are becoming increasingly well documented (Towns et al. 2006, Jones et al. In Press), and they continue to invade historically rat-free islands at the same rate over the last century (Russell et al. In Press-b). As the emphasis on permanent rodent removal (eradication) from islands increases (Howald et al. 2007), there may be a concurrent increase in the rate of rat reinvasion to islands that have recently become rat-free.

To continue keeping rats permanently off rat-free islands, there will need to be an increased emphasis on island biosecurity. In this paper, we outline risk assessment for island invasion by rats, and biosecurity methods that would minimize the risk of invasive rat establishment on rat-free islands. We also describe recent experimental trials where rats were released onto rat-free islands to test biosecurity systems.

RISK ASSESSMENT

Risk assessment considers the likelihood and potential impact of an invasive species establishing in a new location (Andersen et al. 2004). Establishment of invasive species is usually considered along a pathway, which consists of propagule uptake, transport, release, survival and spread (Colautti and MacIsaac 2004). The further along this pathway invasive rats survive, the greater the likelihood of adverse impacts. Unfortunately, there are currently few data available to quantify the relative survival rates of invasive rats through each of these stages. Considering the island as the unit of conservation, pre-border risk assessment considers propagule uptake, transport and release, while post-border efforts consider release, survival and spread.

Invasive rats are transported by human vessels and by natural locomotion (i.e., swimming). All long-distance movements of rats are controlled by uptake, transport and release from ocean-going vessels. Pre-border biosecurity efforts (e.g., by national customs agencies) are required to prevent invasive rats from arriving in new locations via this route. International Health Regulations (2005) require vessels to hold either a current Ship Sanitation Control Certificate or a Ship Sanitation Control Exemption Certificate, which have a life-time of six months. These certificates are issued on behalf of the World Health Organization in order to prevent the spread of contagions, and incorporate the previous (1969) De-rat Certification requirement. This certification provides obvious conservation benefits. Any ship deemed infested by rats shall be fumigated to a standard eligible for certification. Unfortunately, once a ship has cleared quarantine, it is free to move around within national waters, during which time it may transport rats within a region (e.g., from a mainland port to rat-free offshore islands). This kind of rat transportation is beyond the scope of international custom laws. Furthermore, vessels engaged in activities such as illegal fishing within foreign territorial limits increase the risk of unchecked rat transportation. Few data are currently available on the rate of ship infestation by rats. In Alaska, single rats (but not breeding populations) have been detected on large fishing vessels. In the 2006-2007 financial year, 0.3% (2 ships and 8 containers) of 3,119 international vessels entering New Zealand had rats or rat sign (A.Baker, personal communication), while less than 0.2% of 14,200 international vessels inspected entering Australia had live rodents or signs of recent infestation (D. Franks, personal communication). In 1999, ship rats arrived at Clipperton Island off the Baja Peninsula (Pitman et al. 2005), and in 2000, a Korean fishing vessel grounded on rat-free McKean Island, releasing Asian ship rats (*R. tanezumi*) onto the island (M. Thorsen, personal communication).

For islands very close to shore (1-2 km), invasive rat transport can occur by local transportation on vessels or by swimming. It can often be difficult to distinguish the mechanisms by which invasive rats are arriving on islands, although population genetics can provide tools to determine the points of departure (Abdelkrim et al. 2007). Very few data exist on the rates of vessel infestation for local transportation, although in southern New Zealand single rats have been recorded on a number of small vessels in recent years (Russell et al. In Press-b). In New Zealand, better data are available on rat swimming rates, which suggest that rats may swim further and more often than currently believed (Russell and Clout 2005). Invasive rats, particularly brown rats (*R. norvegicus*), can be very capable swimmers (e.g., Russell et al. 2005). Rates of rat arrival at islands can often only be accurately determined following rat eradication. These local movements by invasive rats can be considered post-border in that vessels have cleared international customs, although they remain pre-border in an island biosecurity context, since rats have not yet arrived on the island unit of conservation interest.

Risk assessment for invasive rats on islands balances the likelihood of rat establishment with the potential severity of rat impacts. Rat-vulnerable species often survive, or are 'marooned', on islands (Hutton et al. 2007), contributing to the conservation values of those islands. The application of risk management actions (i.e., biosecurity) essentially becomes a prioritization activity across all rat-free islands, and requires good data on invasive rat presences, transportation likelihoods and the presence of vulnerable species. In New Zealand, biosecurity capacity for invasive rats (as well as other species) has gradually been increased as more islands have become rat-free and the long-term benefits of rat eradication have been observed. This has also essentially made island biosecurity very site-specific. Only recently has a nationwide approach to island classification been adopted by the Department of Conservation in New Zealand (Anonymous 2007).

BIOSECURITY

When a single rat arrives on an island, it is known as an incursion; if other individuals arrive and a population is established, it is an invasion. Biosecurity measures can be implemented as a form of risk management (Andersen et al. 2004), comprising quarantine, surveillance and contingency response. Quarantine involves minimizing the possibility of rat transport during and following arrival on an island. Surveillance includes the actions taken to monitor for rats both on and off islands (e.g., on boats or at points of departure), and requires a long-term, continuous commitment, so that incursions are reliably detected and responded to earlier and hence more successfully. Once there is a quarantine breach or surveillance detection, a contingency response is launched (e.g., Wace 1986). A contingency response is a calculated, and usually expensive and laborious, exercise to eliminate the invading rats using a combination of methods (e.g., Russell et al. 2005). It must be made immediately and with the same intensity as an eradication campaign. Before an incursion actually occurs it is important that the capacity and planning for a contingency response are well in place.

Biosecurity to prevent rat invasion of islands could be prioritized by island invasion rate, economic costs of biosecurity, or costs to biodiversity. We provide an indication of the earliest points where managers may wish to consider biosecurity intervention given different prioritization factors and levels (Figure 1). Biosecurity to prevent rat reinvasion is an on-going and intensive process (Witmer et al. 2007).

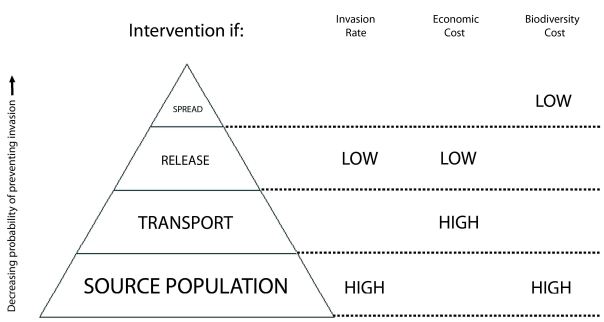

Figure 1. The likelihood of preventing rat establishment decreases the further along the invasion pathway intervention occurs. Earliest points of intervention could be prioritized by levels of invasion rates, economic costs or biodiversity costs.

Two recent reviews are relevant to island biosecurity for invasive rats. Clapperton (2006) reviewed the behaviour of rodents in relation to control devices and emphasized the important differences between the behaviours of the three invasive rat species, which must be considered during biosecurity. Russell et al. (In Press-b) reviewed tools for preventing rat invasion of islands. Rodent behaviour interacts with control devices, which will affect how island biosecurity is undertaken (O'Connor and Eason 2000). In particular, methods that have previously been successful for eradicating rats at high densities may not be appropriate for biosecurity at low densities (Russell et al. 2005). Dense grids of bait stations may be particularly ineffective, as they can evoke neophobia (Russell et al. 2005), be inappropriately designed for rats (Spurr et al. 2006, Spurr et al. 2007) and introduce large volumes of poison to an ecosystem (Hoare and Hare 2006). Additionally, the success of the operation must often be inferred from poison take rather than corpse recovery. Since invading rats usually roam widely (Russell 2007), entry rates of devices are probably more important than encounter rates. Further work is required to develop methods for reliably intercepting invading rats in the presence of other small mammal species.

To test the success of biosecurity systems when there are low densities of invading rats, Russell et al. (In Press-a) released single invading brown rats onto various rat-free islands around New Zealand. A permanent surveillance system of multiple device types was found to be most successful at intercepting invading rats. It took more than 2 weeks to intercept some rats, where it was necessary to launch a contingency response using alternative methods. Complete island coverage enabled close to 100% interception. However, on larger islands where complete coverage is not possible, some rats could evade detection for many months. In the rat-free Pribilof Islands of Alaska, biosecurity around the two main ports consists of traps and poison, and has so far successfully prevented rat establishment despite a number of incursions (Sowls and Byrd 2002). The absence of rat detection does not guarantee that a biosecurity system is successfully preventing rat arrival, however; it may just mean the invasion rate is very low. Releasing a known number of rats onto a rat-free island is a powerful method for testing island biosecurity systems, and could be undertaken following rat eradication before the reintroduction of threatened species. Further work is still required to develop methods for confirming the successful removal of every individual (Kean and Suckling 2005, Morrison et al. 2007).

CONCLUSION

The ability to successfully remove invasive rats from very large islands (up to 11,330 ha) increases the need for effective biosecurity to ensure that reinvasions are prevented. Recent research and management has shown that is it possible to intercept most invading rats within a few weeks of arrival, provided that a suitable biosecurity system is in place. Even islands with relatively high invasion rates (a few rats per year) can be maintained rat-free. Biosecurity is an ongoing intensive exercise requiring the ability to rapidly respond to a suspected incursion with the same intensity as an eradication campaign. For islands that are very close to a source population, invasion rates eventually become so high that even widespread biosecurity cannot prevent rat establishment (e.g., Russell et al. 2007). In this case, islands must be effectively managed as part of a larger meta-population, where ongoing control is required and it is accepted that total 'eradication' cannot be definitively achieved.

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