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Special Issue Article: Tropical rat eradication

Invasive rat interactions and over-invasion on a coral atoll

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ABSTRACT

Invasive rats are found on most island groups of the world, and usually more than one species has invaded. On tropical islands populations of different invasive rat species can co-exist on very small islands, but the population dynamics of such co-existing rat species, their impact on each other, and the mechanisms of coexistence are not well known. This lack of knowledge is a barrier to improving the success rate of tropical island rat eradications. Through an exhaustive trapping eradication campaign on a small tropical island, we study the population structure of historically established *Rattus exulans* where *R. rattus* have colonised within the last fifty years and over-invaded. We contrast this *R. exulans* population with a nearby island population where *R. exulans* exist alone. Recently invaded *R. rattus* numerically and morphologically dominate *R. exulans*; however stable isotope analyses show that the trophic position of *R. exulans* remains consistent regardless of the presence of *R. rattus*, once differences in trophic foundations of islands are accounted for. Although the trophic position of both rat species is indistinguishable, *R. rattus* is able to dominate *R. exulans* through interference competition. Our eradication attempt was interrupted by a tropical cyclone and ultimately unsuccessful, but there is some evidence that *R. rattus* reduced control device availability to *R. exulans,* which has important implications for multi-species control operations.

1. Introduction

Invasions by multiple species with similar functional ecology are becoming more common (Russell et al., 2014). Congeneric invasive rats are one such group of closely related species with a historical checkerboard distribution across islands and continents of the world. Atkinson (1985) records for 123 islands groups, invasive *Rattus rattus* on 50%, *Rattus norvegicus* on 36% and *Rattus exulans* on 24%. The negative impacts of rats on island biota are well documented (Towns et al., 2006) and differ subtly among the three rat species (Jones et al., 2008). Much work has considered the processes by which invasive rat species can co-exist on islands (Yom-Tov et al., 1999; Russell and Clout, 2004; King et al., 2011; Shiels et al., 2013), as well as the related interactions among invasive rats and mice (Caut et al., 2007; Harper and Cabrera, 2010; Bridgman et al., 2013). Subtle differences in competitive ability clearly lead to major differences in the outcome of invasions by multiple rat species.

Eradication campaigns against rats have been successful in temperate regions, but less so in tropical regions, due in part to unique aspects of tropical islands and their rat population dynamics (Holmes et al., 2015), which have resulted in eradication failures and ultimately limited the efficacy of eradication as a conservation tool (Russell and Holmes, 2015). The presence of different crab species on tropical islands, and their complex interactions with invasive rats, is one factor which is considered particularly important (Samaniego-Herrera and Bedolla-Guzmán, 2012). Better understanding of the population structure and dynamics of invasive rats on tropical islands would help conservation managers plan and optimise island eradication campaigns (Keitt et al., 2015). However, the population structure and dynamics of invasive rats differs among island groups depending upon the climatic region, and within island groups depending on the coexistence of other predators and competitors, particularly other introduced mammals (Russell et al., 2011b; Ringler et al., 2015). Aerial eradication campaigns often preclude simultaneous study of the population ecology of the target population. In contrast experimental-type eradications on small islands where the population is first trapped to 'zero density' before remaining survivors are eradicated with poison, have been very powerful for advancing our knowledge on

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the population dynamics of invasive rats (Lorvelec and Pascal, 2005; Russell et al., 2009b).

Our study took place on a small tropical island (Honuea), on an atoll in the Society Islands of French Polynesia, where the history of rat invasion is well-known. *R. exulans* have been historically present for at least a hundred years, probably longer, until *R. rattus* arrived and over-invaded (a process whereby one invasive species displaces another *sensu* Russell et al., 2014), as occurred commonly throughout the Pacific. The study had two main goals. The first goal was to enumerate an entire tropical island population of co-existing invasive *R. exulans* and *R. rattus* by comprehensively trapping rats as part of an eradication campaign. This intensive trapping program was intended to provide data on tropical island rat population structure (e.g. density and morphology) and the differences in trophic ecology of two co-existing invasive rat species. The second goal was to contrast the population structure and trophic ecology of invasive *R. exulans* on our island (Rimatuu) of experimental eradication with a second island where they existed in the absence of *R. rattus*. This comparison was intended to determine whether the arrival of a second congeneric invasive species might substantially alter the population structure and trophic position of the incumbent invasive species.

2. Materials and methods

2.1. Study site

Honuea is a 28 hectare uninhabited island located in the Tetiaroa atoll (Fig. 1). The vegetation of Honuea consists of dry primary succession forest and can be divided into the eastern more open abandoned coconut plantation (*Cocos nucifera*), and the western area occupied by dense patches of pandanus (*Pandanus tectorius*), both coastally fringed by *Guettarda speciosa* and *Heliotropium foertherianum* (previously *Tournefortia argentea*). *R. exulans* existed alone on Honuea for at least a hundred years until *R. rattus* colonised the island in the early 1970s (Russell et al., 2011a). Rimatuu is an 88 hectare island also located in the Tetiaroa atoll, 2 km from Honuea. The vegetation of Rimatuu is more varied and disturbed, including coconut trees, *G. speciosa*, *Morinda citrifolia* and a range of other species which reflect its history as the main island of Polynesian occupation and modification on Tetiaroa. *R. exulans* have existed alone on Rimatuu for over a hundred years. The recent history of the entire atoll is described elsewhere (Russell et al., 2011a).

2.2. Fieldwork

During 7–9 July 2009 a line of up to 30 kill traps (Victor Professional) placed every 50 m was laid around the coast of Rimatuu for three nights as part of an atoll wide rat survey (Russell et al., 2011a). During 20–27 January 2010 a grid of 118 stations with traps every 50 m was laid across the entirety of Honuea for 7 nights as part of an experimental eradication campaign. This grid alternated live (Manu, France; $n = 59$) and kill (Victor Professional; $n = 59$) traps due to limited availability. All live rats captured were immediately euthanized. All rats caught were identified to species, sexed, weighed (500 g Pesola) and had standard morphological measurements of head–body length and tail length taken (to the nearest millimetre). Tissue samples were taken from all rats captured.

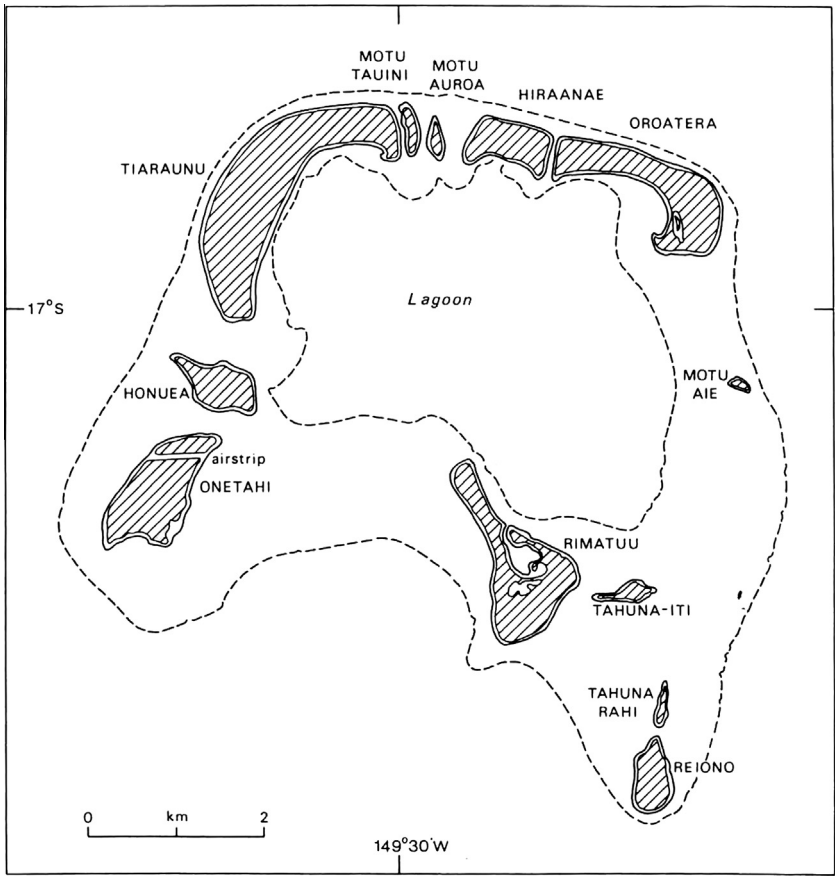

Fig. 1. Tetiaroa atoll (3366 ha; 17°05′S, 149°30′W), lies 50 km north of Moorea and Tahiti in the Society Islands of French Polynesia. The atoll comprises 12 vegetated motu (small islands) and an emerging sandbank (Motu One) east of Tahuna Iti, all circling a large lagoon. *Source:* David Stoddart.