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The Ant Fauna of Rakitu (Arid Island), New Zealand

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Abstract

Monitoring the fauna of an island before ecological restoration work begins provides a baseline against which changes to that environment can be quantified. Ants are a diverse and ecologically important group of insects, and many are extremely successful invasive species. In this study we provide the first description of the ant fauna of Rakitu (Arid Island), a small island in the outer Hauraki Gulf of New Zealand. We used a combination of unbaited pitfall traps, baited stations (rat traps with peanut butter) and hand searching conducted in habitats across the island. Using morphological classification and genetic barcoding we detected seven species of ant: four New Zealand endemics (*Austroponera* sp., *Heteroponera brouni*, *Monomorium antarcticum*, and *Monomorium antipodum*) and three introduced (*Iridomyrmex suchieri*, *Ochetellus glaber*, and *Tetramorium grassii*). While the ecological effects of these introduced species are currently unquantified, none of them have previously been highlighted as likely ecological threats. Our results provide a baseline for future biosecurity monitoring of the island, and can be used to help assess changes in the environment related to the forthcoming removal of invasive rat species from Rakitu.

Introduction

Understanding the initial fauna and flora of an island before ecological restoration actions begin, such as invasive species eradication, is critical in order to understand the long-term effects of these programmes (Jones et al., 2016). The invertebrate fauna are often neglected in these ecological monitoring programmes, however, quantifying them is critical to understanding ecological function (Rosenberg, Danks, & Lehmkuhl, 1986; Sheehan, Székely, & Hilton, 2011; Sinclair et al., 2005). One specific area that requires addressing in these ecological monitoring programmes is assessing the presence of other invasive species – enabling these existing species to be managed if required, and providing a baseline knowledge of the fauna so that novel incursions can be identified rapidly before their populations expand.

Many ants are extremely successful invasive species with serious agricultural, social and environmental impacts throughout the world (Holway, Lach, Suarez, Tsutsui, & Case, 2002; Williams, 1994). New Zealand's native ant community is composed of eleven endemic species, along with a total of 37 introduced species (Don, 2007), including the invasive Argentine ant *Linepithema humile* (Ward et al., 2010). Understanding the spread and ecological effects of invasive ants in New Zealand is critical for both biosecurity and ecological restoration (Harris & Baker, 2007; Lester, 2005; Ward, Beggs, Clout, Harris, & O'Connor, 2006).

Ecological restoration programmes involving mammalian eradication are increasingly common on islands in the Hauraki Gulf, and these islands experience ever-increasing challenges to their biosecurity (Bassett, Cook, Buchanan, & Russell, 2016). A good example of this is Rakitu (Arid Island), a 328-hectare island in the outer Hauraki Gulf lying 2.5 kilometres off the east coast of Aotea (Great Barrier Island). It is a highly modified island, with areas of thick rank grass, scrub and patches of mature coastal broad-leaf (Cameron & Wright, 1982). Rakitu presents great potential for ecological restoration if invasive species can be eliminated and if biosecurity systems can be implemented to prevent their reintroduction. The last major terrestrial ecological survey was undertaken in January 1981 by the Offshore Island Research Group, and was published in Volume 28 of the University of Auckland journal *Tane* (Hayward, 1982). While many taxa were surveyed during this trip, invertebrates were not surveyed, and very little is known about this fauna.

The management history of Rakitu has meant that

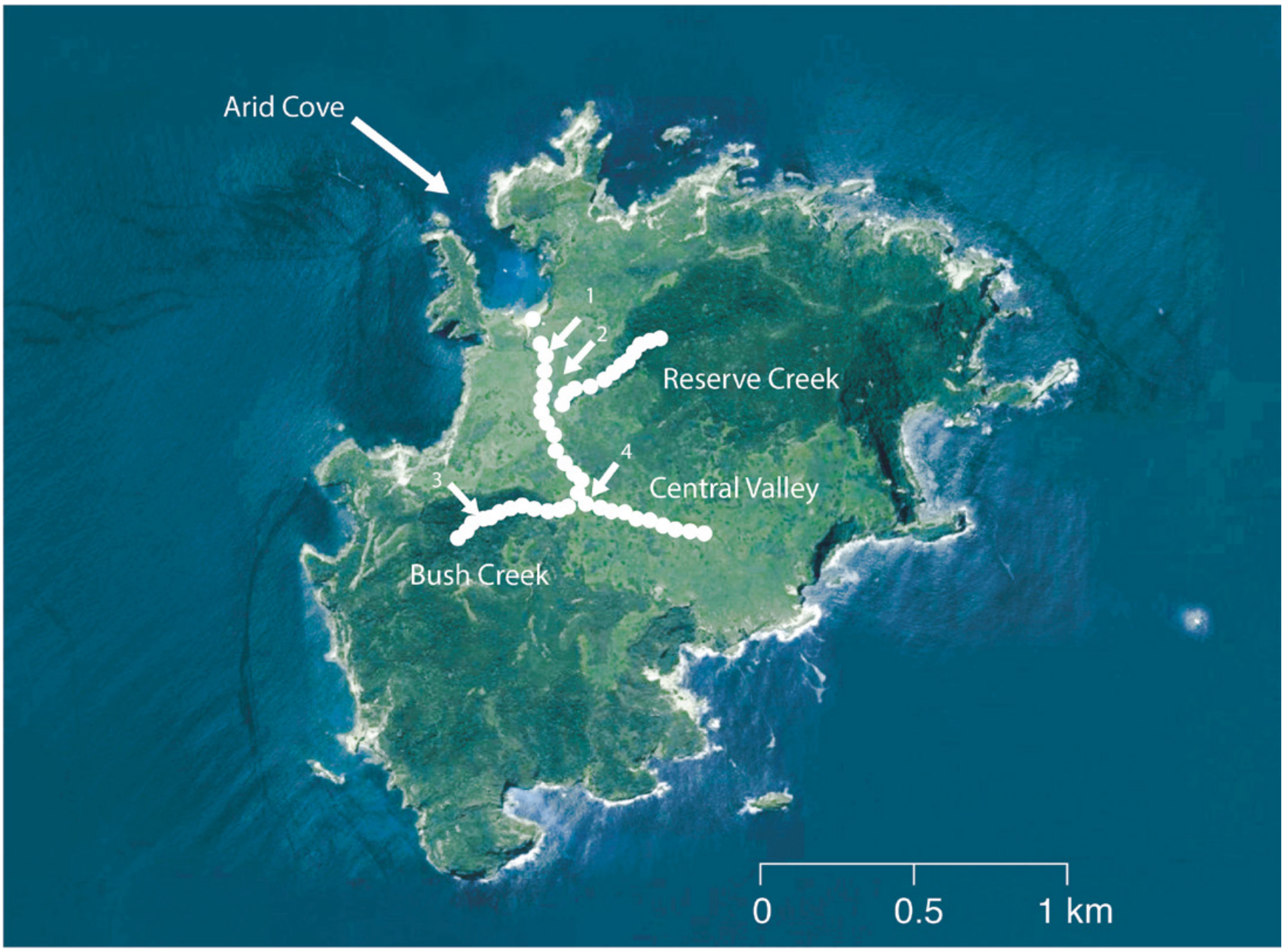

Figure 1: White circles indicate the Rakitu Island monitoring stations. The Reserve Creek and Bush Creek lines had both rat traps and pitfall traps, the Central Valley line only had rat traps. The numbers correspond to the single locations where four of the ant species were detected. 1: *Ochetellus glaber*; 2: *Iridomyrmex suchieri*; 3: *Heteroponera brouni*; 4: *Monomorium antarcticum*.

it is likely that many invertebrate species have been accidentally introduced; farm equipment and building supplies were brought to the island with minimal biosecurity awareness over the last century, and until recently there have been no formal biosecurity protocols for landing there. Since 1994 it has been in government ownership and managed as a Department of Conservation scenic reserve, allowing unrestricted public access. Arid Cove (Figure 1) is a popular sheltered anchorage, with public vessels regularly landing on the island – again, often with no knowledge of or consideration towards biosecurity and the prevention of novel insect establishment. A rat eradication operation is currently underway for Rakitu Island with the hope of restoring the island's indigenous fauna and re-establishing a seabird-driven ecosystem. Invasive ants have the potential to significantly impact New Zealand ecosystems, and specifically the ecology of seabird islands (Fukami et al., 2006; Plentovich, Hebshi, & Conant, 2009); therefore assessing the current ant fauna of these islands and monitoring for new invasive ants should be prioritised. It has previously been demonstrated that some invasive ant species (in this instance yellow crazy ants) have benefitted from rodent eradication operations (Feare, 1999). The specific mechanisms behind the interactions between invasive rodents and ants are yet to be properly studied, with a multitude of changes in the seed and seedling density, and increasing densities of large insect fauna likely to occur due to rodent removal (Watts, Armstrong, Innes, & Thornburrow, 2011).

Our aim in this study was to identify the ant fauna on Rakitu Island, and to provide a baseline for future biosecurity and ecological monitoring studies. This study was undertaken opportunistically while conducting a range of monitoring as part of the pre-rat-eradication biodiversity survey.

Methods

Three methods were used to detect ants across the island over a four-day surveying trip in January 2018: pitfall traps, baited traps and hand searching. The 24 pitfall traps were laid out in two transect lines, each starting in the kikuyu grass in the central valley, proceeding through the scrub and up into the surrounding remnant coastal broadleaf forests of Bush Creek and Reserve Creek (Figure 1). Two transects consisting of a total of 36 Victor Professional rat snap traps spaced every 50 metres, baited with peanut butter (Eta), were set to monitor rodent presence across the island. One of these transects (24 traps) followed the path along the central valley primarily through kikuyu grass and scrub habitat, while the other (12 traps) followed the pitfall traps through the forest of Reserve Creek, with traps located ~5 metres from pitfall traps. During the course of the rat-trapping work over two nights, ants were gathered on the peanut butter food resource on the traps. These ants were then shaken off the traps into plastic bags and stored in 70% ethanol. Hand searching was also conducted opportunistically at selected locations around the buildings in Arid Cove to detect potentially recently arrived ants.

Species identification

The ants sampled were identified morphologically to species level using the New Zealand ant key (available online from the Landcare Research website). DNA from the head, thorax and legs of representatives of each species was extracted using a DNeasy Blood & Tissue Kit (Qiagen). We used the standard universal COI primers LCO1490 and HC02198 (Folmer, Black, Hoeh, Lutz, & Vrijenhoek, 1994) to amplify the barcoding region of COI, and sequenced these PCR products in both directions using a BigDye Terminator Cycle Sequencing Kit, analysed on a 3130xL Genetic Analyser (Applied Biosystems). The reads obtained were then aligned and concatenated in Geneious 9.1.8 (Biomatters).

Results

We identified seven species of ant on the island: four native and three introduced (Table 1, Figure 2). Note that the single *Iridomyrmex suchieri* specimen is a queen (no workers were found of this species) therefore the size comparison to the other species is somewhat

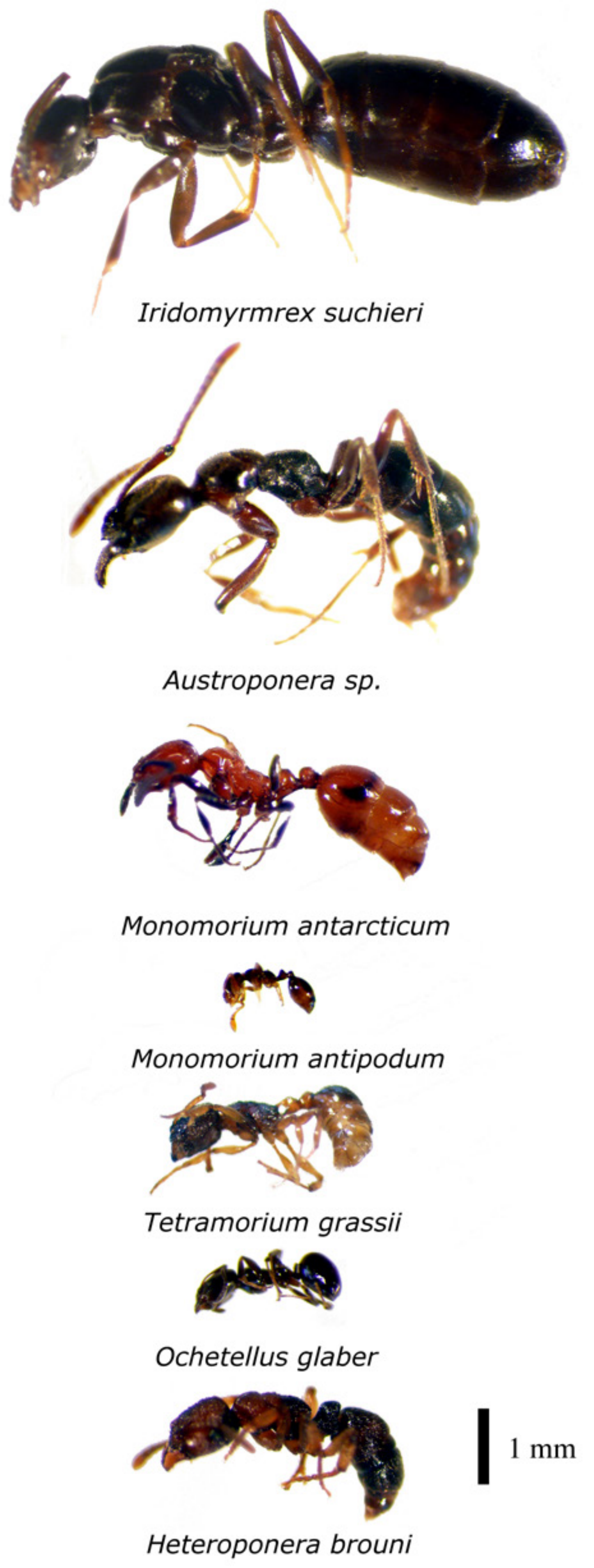

Figure 2: Ant species recorded on Rakitu. Note the pictured *Iridomyrmex suchieri* individual is a queen rather than a worker as for the other species.

Species	Status	Locations	GenBank #
Austroponera sp.	Endemic	9/20 pitfall traps, also occasionally on rat traps	MH539773
Heteroponera brouni	Endemic	1/20 pitfall traps, not recorded on rat traps	NA
Monomorium antarcticum	Endemic	10/20 pitfall traps, very common on rat traps	MH539776
Monomorium antipodum	Endemic	0/20 pitfall traps, 1 rat trap	MH539775
Iridomyrmex suchieri	Introduced	0/20 pitfall traps, 1 individual found in woodpile by house	MH539774
Ochetellus glaber	Introduced	0/20 pitfall traps, 1 rat trap	MH539777
Tetramorium grassii	Introduced	16/20 pitfall traps, very common on rat traps	MH539778

Table 1. Ant species present on Rakitu Island

misleading. We successfully obtained COI sequences from most of these species: GenBank accession numbers in Table 1. The one exception that was not sequenced was *Heteroponera brouni*, where the DNA from the two individuals caught appeared too degraded to amplify.

Two species (*Monomorium antarcticum* and *Tetramorium grassii*) were common across the island, dominating both the rat traps and pitfall traps across grass, scrub and forest habitats. One other species (*Austroponera* sp.) was also common across all habitats, but it was less abundant than the previous two. The other four species were only found in one location each: *M. antipodeum* was recorded at one rat trap in the central valley among thick kikuyu grass, *Ochetellus glaber* was only recorded at one rat trap in scrub, and *Heteroponera brouni* was only recorded in one pitfall trap in forest in thick leaf litter. The single *Iridomyrmex suchieri* specimen was found by hand searching in a wood pile below one of the houses. On most of the rat traps, only one species of ant was recorded.

Discussion

Most restoration islands (and mainland sanctuaries) in New Zealand have not had ant surveys published, and the composition of the general invertebrate fauna on these islands is rarely described – with a few exceptions, e.g. Elliott, Greene, Nathan, & Russell, 2015; Russell, 2012; Russell, Horn, Harper, & McClelland, 2018; Sinclair et al., 2005. This means that changes over time in the invertebrate fauna composition are difficult to quantify, and detecting novel invasive invertebrate species is similarly neglected. We need to move towards more complete faunal surveys for restoration islands, so that we can better monitor the outcomes of interventions such as mammalian eradication operations, and to have better baseline data to help detect novel incursions.

This study is the first to examine the ant fauna of Rakitu, and it was conducted six months before rat eradication in winter 2018. The native ant species present on Rakitu are all common species naturally occurring in northern New Zealand. *Monomorium antarcticum* is New Zealand's most ubiquitous native ant species, found throughout the North, South, Stewart, and on many other offshore islands (Don, 2007). This species is highly variable in size and colour, and comparative analyses of poison gland alkaloids suggest that this is potentially a species complex of at least four species (Don & Jones, 1993; Jones, Stahly, Don, & Blum, 1988). *M. antipodum* is a small non-aggressive species that is probably endemic to New Zealand, and it is widely distributed in the northern South Island and across the North Island. *H. brouni* is a New Zealand endemic, primarily found in the northern North Island and on nearby offshore islands including Great Barrier Island (Don, 2007). Its ecology is poorly known, but it is a native forest dweller nesting in soil under leaf litter and in rotting logs. The *Austroponera* sp. found on Rakitu Island was not identified to species level, as there is considerable morphological overlap between *A. castanea* and *A. castaneicolour* (Don, 2007). The COI sequence published here will potentially help elucidate the identity of this species once more genetic resources become available for this genus. Both of these *Austroponera* species are common across the northern South Island, the North Island, and on many offshore islands, and are both endemic to New Zealand.

None of the introduced species are known to be major pests – though the ecological effects of all of these species have yet to be properly described. Importantly, we found no evidence of the invasive Argentine ant (*Linepithema humile*), though as populations of this species can be highly localised we cannot fully rule out its presence somewhere on the island. The most common introduced ant on Rakitu was *T. grassii*, which originally came from South Africa and was first recorded in Auckland in 1958 (Brown, 1958). It is now very common across Auckland and Northland. Don (2007) describes it as "a mild-mannered ant similar in appearance and behaviour to *M. antarcticum*". Currently these two ant species appear to co-exist on Rakitu Island, despite a probable similar niche. *Ochetellus glaber* is an Australian import, and though its impacts on native habitats are unknown it is not considered a major pest. It is commonly collected along the margins of forest and scrub around the northern North Island – particularly around Auckland (Don, 2007). *Iridomyrmex suchieri* is an Australian endemic which prefers open ground, and it may have the potential to displace other native ants due to its aggressive nature. Again, little is known about the potential impact it could have on native habitats and ant species assemblages.

Both *Iridomyrmex suchieri* and *Ochetellus glaber* were only found in one location each, and both of these locations were close to the buildings in Arid Cove indicating a possible recent invasion. In particular the *Iridomyrmex suchieri* was associated with recent human activity, being found among imported wood below the occupied house. This pattern means that both of these species may have yet to spread to their potential range on the island. Further monitoring of their populations and spread may be warranted.

The barcoding COI sequences generated in this study will be useful for future ant surveys in New Zealand. *Monomorium antarcticum*, *M. antipodum* and *Ochetellus glaber* already had published COI sequences on GenBank (with vouchers most closely matching our sequences: 94-99% identity). Of these three ant species, *M. antarcticum* was the only one that had an identity to the published sequence of less than 98% – it was 94%. Generally ant species have >98% identity at COI within the species. This result therefore reinforces the belief that there are multiple cryptic species within the current circumscription, therefore this species requires further taxonomic work. The COI sequence available on GenBank for *M. antarcticum* (GenBank # KJ847471.1) is from a PhD thesis that does not give the location, a picture of the specimen, or description of the morphology of the individual sequenced (Sparks, 2015). The author does however note the high probability of multiple species within the currently circumscription of the species as suggested by Don & Jones, 1993, and Jones et al., 1988. Sequences closely matching (99% identity) our *Austroponera* sp. sequence have been recorded from the nearby island of Te Hauturu-o-toi (Little Barrier Island) in eDNA samples of soil insects (which had not been identified to species level but are likely to be the same species) (Drummond et al., 2015). There were no published COI barcode sequences for *Tetramorium grassi* or *Iridomyrmex suchieri*, though sequences from close relatives (*Iridomyrmex anceps* and *Tetramorium humbloti*) were available to help confirm genus identification.

This ant faunal survey should be regarded as preliminary, and it is likely more species occur on the island than were documented. Four of the recorded species were only recorded from one location each – highlighting the low chance of detection and/or patchy distribution for many species. Ant species can competitively exclude each other from food resources, therefore only the most common or dominant species may be recorded at baited stations (Stringer, Suckling, Mattson, & Peacock, 2010). This may have occurred in our study, with *Tetramorium grassii*, *Monomorium antarcticum* and *Austroponera* sp. all potentially excluding other species from the baited rat traps. While these three species dominated the rat-trap sampling, they also dominated the pitfall trapping, increasing the evidence that they are among the most common ground-dwelling ants on the island.

Ideally, standardised sampling using hand searches and litter sampling with Tullgren funnel extraction would have complemented the bait stations and pitfall traps. However, as this study was undertaken opportunistically while focusing on other biodiversity monitoring, this more thorough survey was not conducted. Future studies on the ant fauna of Rakitu should employ these more defined survey techniques.

With the imminent eradication of rats from Rakitu, biosecurity measures must be implemented and maintained in order to prevent mammalian reinvasion. This increased biosecurity should extend to invasive invertebrate species in order to maximise the potential to restore the island's ecosystems. Along with better biosecurity at ports of origin, detection devices should be maintained in Arid Cove and around the buildings in order to detect novel ant species incursions, enabling these to be eradicated before they spread.

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