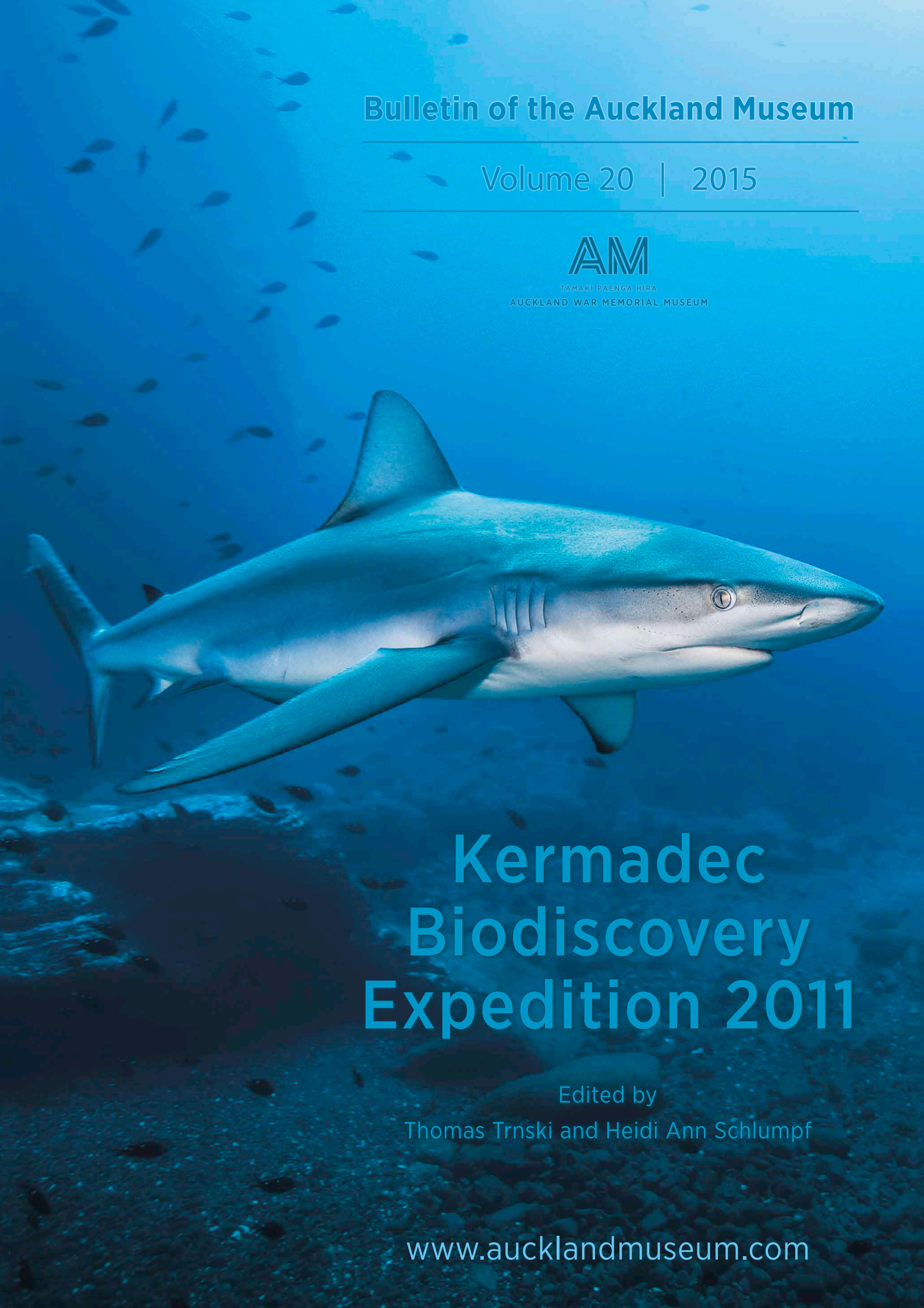




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The Kermadec Islands terrestrial invertebrate fauna: Observations on the taxonomic distribution and island biogeography

Warren G.H. Chinn Department of Conservation

Abstract

A sample of terrestrial invertebrates from the Kermadec Islands is reported on. Specimens were acquired as part of a marine biodiversity expedition in May 2011, consisting of: 118 recognisable taxonomic units; 12 unrecognised taxa and 47 species with new location records. Seven of the 15 Kermadec Islands were visited, including Raoul, the twin Meyers, North Chanter, Macauley, Cheeseman and L'Esperance Rock. Of these, only Raoul, the Meyers and Macauley Islands have received previous entomological attention. The level of endemism is extremely low, and most of the Kermadec Island fauna is also found elsewhere in the south Pacific which comprises highly mobile taxa. The taxonomic composition of the four most isolated islands is examined by class and shows a reduction of groups associated with land area. A species area curve suggests the Kermadec Islands are consistent with the theory of island biogeography, demonstrating a positive relationship ($r^2=0.4538$) between the number of taxa and island size. Inter-island dispersal is examined using the percentage of shared taxa correlated with distance between islands. A weak negative relationship (-0.164) suggests that distance is a minor barrier, while habitat suitability may be more significant and could operate as an ecological filter. These interpretations highlight the value of the island group as a biogeography laboratory while reinforcing their conservation value.

Keywords

Kermadec Islands; Raoul Island; Macauley Island; Cheeseman Island; Curtis Island; L'Esperance Rock; invertebrate fauna; diptera; araneae; orthoptera; island biogeography; species area relationship

INTRODUCTION

The Kermadec Islands are a chain of emergent volcano summits, equidistant between New Zealand and Tonga. The group has four main islands including (from north to south): Raoul, Macauley, the Curtis and Cheeseman pair and L'Esperance Rock (a sea stack). Raoul, the largest island at 2938 ha, has a number of satellite islets no further than five km to the northeast. These smaller islands include the North and South Meyers, the Herald Islets including Dayrell, and the Chanter Islands (North and South). Completing the group are Napier and Nugent Islands, the most northern lands in the New Zealand realm (Fig. 1). The Kermadec Islands are geologically young, emerging no more than 0.5–1.5 million years ago as a volcanic arc, 100 km west of the Kermadec subduction trench. The geology comprises basaltic andesites, layered ignimbrites with tephra, ash deposits and, in several locations, uplifted sedimentary series (Lloyd & Nathan 1981).

Raoul Island supports the richest assemblage of plant species among the group, with forest cover dominated by endemic pōhutukawa (*Metrosideros kermadecensis*),

ngaio (*Myoporum rapense* subsp. *kermadecense*) and nīkau (*Rhopalostylis baueri*); elements shared with New Zealand, Norfolk Island and, to some extent, Lord Howe Island. At present, Macauley Island is almost entirely clothed in the sedge *Cyperus insularis* and the fern *Hypolepis dicksonioides* and a sparse but regenerating population of *Homalanthus polyandrus* (Kermadec poplar). Further south, Cheeseman and Curtis Islands present a salt-tolerant, prostrate vegetation on highly skeletal and friable soils. Conspicuous plants include grasses (*Cyperus insularis*), the ice plant (*Disphyma australe* subsp. *stricticaule*), *Lepidium castellanum* and nightshade (*Solanum nodiflorum*), (Barkla *et al.* 2008; Sykes 1969; Oliver 1910; de Lange (2015a, b).

At the southern end of the Kermadec Islands is L'Esperance Rock, an isolated basalt stack, regularly doused in rain and sea water thrown up by cyclones, a process that has effectively confined any flora to sheltered enclaves and crevices. The skeletal soils of the rock provide sufficient refugia for northern shore spleenwort (*Asplenium northlandicum*), ice plants and the nationally critical *Senecio lautus* subsp. *esperensis* (de Lange 2015c); however the terrestrial micro fauna of L'Esperance Rock

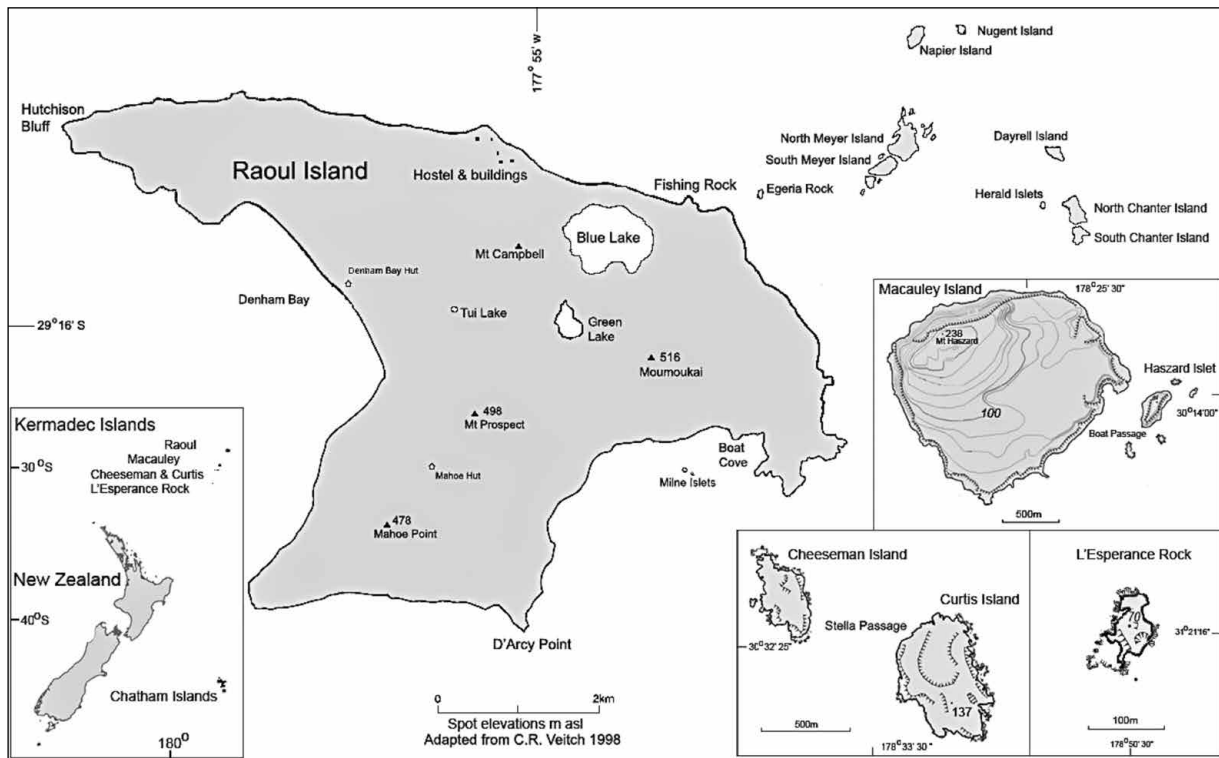


Figure 1. Map of the Kermadec Islands including islands visited during the May 2011 biodiversity expedition.

is otherwise largely unknown. The ecological value of the Kermadec Islands has been recognised for many years and the islands were designated a nature reserve in 1934 and, in 1990, New Zealand's largest marine reserve was established around the group.

Previous invertebrate surveys

Invertebrate collecting on the Kermadec Islands appears to be limited to Raoul, the Meyers and Macauley Islands (Watt 1975a and references therein; Greene *et al.* 2004). Charles Watt provided a general introduction to the arthropod fauna of the Kermadec Islands, describing it as "...rather poor and fragmentary" with close affinities between Australia, Tonga and northern New Zealand (Watt 1975a, b). Invertebrate endemism is very low (perhaps less than 1%, this work), while adaptive radiations are apparently non-existent, with the fauna dominated by small flying forms or those that are easily distributed across large ocean distances (via ballooning, wind, floating or phoresy). Undoubtedly, these characteristics are the product of the islands' small areas, isolation and high frequency of disturbance from cyclones, intense erosive rainfall, volcanic eruptions and earthquakes. It is also these very characteristics that make the Kermadec Islands an outstanding natural history laboratory in which to examine several ecological themes.

Human impacts on the Kermadec Islands

Evidence of the first humans to visit Raoul Island suggests that Polynesian seafarers arrived between 550–650 YBP, voyaging to and from Rarotonga and New Zealand. These travellers referred to Raoul Island as Rangitahua, yet no

long-term settlement on the islands is apparent (Higham & Johnson 1996). Kiore, the Polynesian rat (*Rattus exulans*), was probably introduced to the islands at this time, becoming established throughout Raoul (Harper & Veitch 2006). Whalers occasionally made landfall in the early 1800s and, despite several valiant attempts to settle on Raoul Island during the late 1800s (notably the Bell family and others, see Morton 1957 and Gentry 2013), permanent occupation on the island was achieved only in the 1930s. Currently, the New Zealand Department of Conservation (DOC) maintains staff year-round on Raoul Island, primarily to operate the meteorological station and to maintain weed and pest control.

During the late 1800s, goats were released on Raoul and Macauley Islands (as a food supply for sailors and whalers) and it is likely that the feral cat population also became established at the same time. The combination of rats, cats, goats and weeds had significant ecological impacts that were apparent for decades and included predation, weed spread and widespread herbivory. Goats were eventually removed from Macauley Island by the NZ Wildlife Service in the 1960s and 70s and, from the late 1980s to the present, the Kermadec Islands have been managed by DOC. Goats were finally eradicated from Raoul Island in the 1980s along with other pests but rats and feral cats remain a threat to invertebrate and bird life.

Complete eradication of pests from Raoul and Macauley Islands began in 2002 and was, at the time, the largest operation of its kind in New Zealand. Considerable effort was put into pre-operational research, as there were concerns that weeds may become more invasive following the removal of rats as important seed predators

(West 2011), and that brodifacoum poison (to eradicate kiore) might impact the island's population of Kermadec Islands parakeet (*Cyanoramphus novaezelandiae cyanurus*). For that reason, a trip to Macauley Island was mounted in 2002 by DOC staff, who also made entomological notes (Greene *et al.* 2004).

THE 2011 BIODIVERSITY EXPEDITION

The material for this work was collected during a May 2011 biodiversity expedition to the Kermadec Islands. A collaborative venture between the Auckland Museum (AM) and the Australian Museum in Sydney (AMS), the expedition was organised by marine biologist Tom Trnski (AM). The aim was primarily a marine survey and the terrestrial component was at the initiative of plant taxonomist Peter de Lange (DOC), who made a case for more information about Kermadec Islands terrestrial invertebrates (see Trnski and de Lange 2015).

This paper reports on new location and species records from islands that are rarely visited or from which collections are not known. An approach was also made to address the following biogeographic questions: Which invertebrate groups are present on the outlying Kermadec Islands; to what extent do the islands conform to the species area rule; and what degree of species sharing and exchange is occurring between the islands?

Methods

The survey was a non-quantitative, rapid biodiversity assessment, using hand, pooter, sweep netting and beating to collect invertebrates. During longer stays on the islands, yellow pan traps, a light trap and a malaise were employed. Invertebrates were collected from Raoul, the Meyers, North Chanter, Macauley, and Cheeseman Islands, and L'Esperance Rock. Making landfall on the smaller Kermadec Islands is a demanding operation and success is dictated by tide, swell and winds. We were

put ashore using small custom-built craft and successful landings depended entirely on the skill of the boat operators. Specimens from the survey are lodged with the Auckland Museum, Auckland; Lincoln University Entomology Museum and the New Zealand Arthropod collection, Landcare Research.

Results

The collection

One hundred and eighteen (118) taxa in 110 genera were collected (a 1:1.07 genus to species ratio). Twelve taxa were unrecognised and are potentially new species, of which nine types were flies. Forty-seven recognised taxa are considered new records for the Kermadec Islands (see Table 1 for summary data per island; and the Appendix, for a species check list). At least five species collected are endemic to the islands, including: the earthworm *Megascolex laingii*, a centipede *Lamyctes kermadecensis* and the terrestrial snails *Tornatellides subperforatus* sub.sp. *kermadecensis*, *Tornatellinops iredalei* and *Pronesopupa senex* (each listed as data deficient on the DOC threat ranking system Hitchmough *et al.* 2007).

Flying insects were disproportionately represented on the islands (69%), the top three orders being diptera (24 spp.), coleoptera (10 spp.), and lepidoptera (8 spp.). Arachnids proved to be the second most abundant group (15%), with 17 species of araneae. Terrestrial molluscs, myriapoda and isopoda completed the taxonomic suite, with notably fewer species but higher rates of endemism.

Invertebrate composition on the outlying islands

Invertebrate classes observed and the proportion of species represented on Raoul, Macauley, and Cheeseman Islands, and L'Esperance Rock are summarised in Fig. 2. The Meyers and North Chanter Islands were omitted from this analysis because of their close geographic proximity to Raoul Island (a biotic reservoir, biasing the

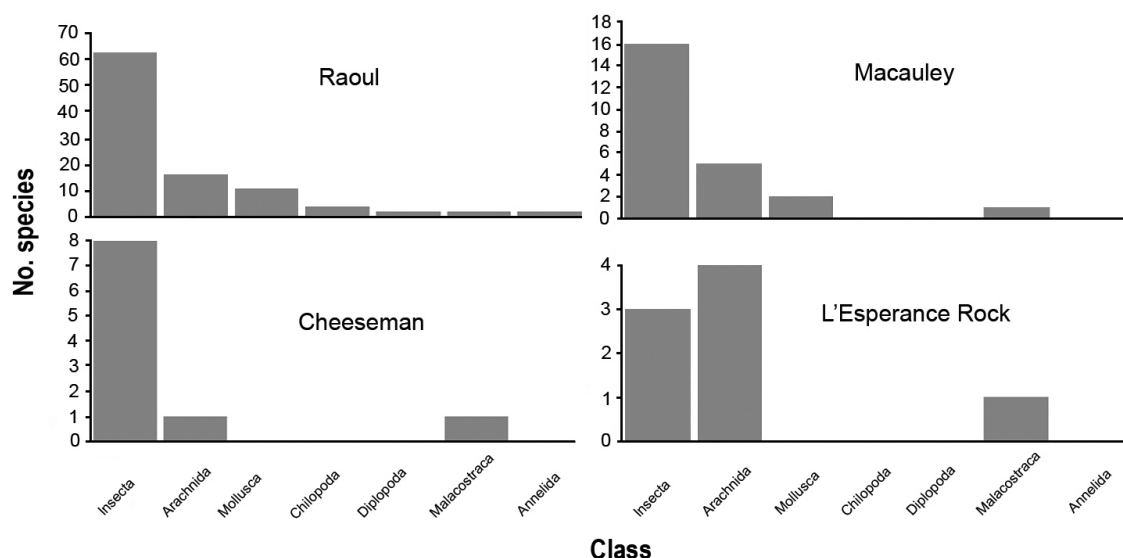


Figure 2. Bar plots showing number of species per taxonomic class per island for the Kermadec Islands. Data show the four islands with widest range of area and geographic isolation.

Table 1. Summary data table of the Kermadec Island terrestrial invertebrate records from the 2011 biodiversity expedition.

	Raoul	Meyers Is	North Chanter I.	Macauley I.	Cheeseman I.	L'Esperance Rock
Hectares (km ²)	2938 (29.38)	8 (0.08)	5 (0.05)	308 (3.08)	7.6 (0.076)	5 (0.05)
Date of visit	May 15-16 & 18-19, 2011	May 12-13, 2011	May 16, 2011	May 21-23, 2011	May 24, 2011	May 26, 2011
Number of days and/or hours collecting	3 days/16 hrs	4 hrs	2hrs	2 days/8hrs	3hrs	2hrs
No. of RTU's collected per island	87	13	7	26	11	9
Number of potentially new species	7	2	0	1	1	1
	Araneae	Diptera		Psychodidae sp.	<i>Fannia</i> sp. (Fannidae)	<i>Protocheliifer</i> sp. (Cheliferidae)
	<i>Hulua</i> sp. (Desidae)	Sphaeroceridae sp.				
	Diptera	<i>Fergusonina</i> sp. (Fergusoninidae)				
	<i>Paradasyhelea</i> sp. (Ceratopogonidae)					
	<i>Achalcus</i> sp. (Dolichopodidae)					
	<i>Hydrellia</i> sp. (Ephydriidae)					
	<i>Atherigona</i> sp. (Muscidae)					
	<i>Megaselia</i> sp. (Phoridae)					
	Gastropoda					
	<i>Flammulina</i> sp. (Charopidae)					
No. of endemic taxa	5	0	0	1	0	?
No. of species with new location records	33	4	7	17	11	8
No. of species with flightless forms	42	6	1	8	3	3

composition of taxa on the outlying islets). Of note is the dominance of insects on all islands except L'Esperance Rock, where arachnids were the principle group. The number of taxonomic classes per island declined between Raoul Island and L'Esperance Rock at an estimated one class per 570 ha. Centipedes, millipedes and earthworms were not recorded from Macauley Island, a trend that continued with the absence of snails on Cheeseman Island. The remaining classes on L'Esperance Rock were insects, arachnids (mites, spiders and a pseudoscorpion) and slaters (malacostraca).

Among the flying insects, diptera and coleoptera were common throughout, although on L'Esperance Rock, orthoptera, thysanurans and diptera were the rule. The flightless scale cricket *Ornebius kermadecensis* was present on all islands and, by contrast, only one butterfly (the Yellow Admiral *Vanessa itea*) was seen on Macauley Island, although Lepidoptera were in substantial numbers on Raoul Island.

Biogeographic analysis

A species / area plot was constructed and shows a positive association between the number of taxa collected and island area. Raoul Island produced the highest yield of invertebrates (including diversity and biomass), with the least from L'Esperance Rock (Fig. 3). Data are expressed as catch per hour to adjust for differing search durations per island. Of note is the proportionally higher number of taxa collected from the Meyers and North Chanter, islands of similar area to Cheeseman and L'Esperance, yet no further than five km from Raoul Island. The relationship between island distances and the proportion of taxa shared is shown in Figure 4. A weak negative correlation (-0.164) was generated using pairwise shared taxa and geographic distances. There were several outliers and the data were widely scattered about the trend line ($R^2=0.164$).

Ecological notes on the outlying islands

The Meyer Islands

Collecting on the Meyer Islands appears to be restricted to Samuelson's 1962 trip (Samuelson 1975) and Watt's 1967 visit (Watt 1975a). The twin islands comprise steeply sloping basalt and breccias with deep, red oxide soils. The highest points are approximately 40 m a.s.l. on both Meyer Islands which support open forest of Kermadec pōhutakawa, ngaio, karaka (*Corynocarpus laevigatus*) and mahoe (*Melicactus ramiflorus*) (Fig. 5A). At the time of our visit, weeds were spread throughout the islands, in particular the introduced 'blue billy goat weed' *Ageratum houstonianum* and two herbaceous nightshades, *Solanum nigrum* and *S. nodiflorum*, both competitive excluders of the endemic *Senecio kermadecensis* (P. de Lange, May 2011 pers. comm.). Hundreds of ground-nesting Kermadec petrels (*Pterodroma neglecta*) and red-tailed tropic birds *Phaethon rubicunda* were resident on the islands and the bioturbation of soil was prodigious.

The earthworm *Allolobophora caliginosa* was relatively common in the least disturbed soils and was confined to damp aspects. Similarly, the punctid snail *Paralaoma servilis* was found to be associated with damp and woody material. All spiders collected are found elsewhere, either in New Zealand or eastern Australia and included: *Eriophora pustulosa* (araneidae), *Lampona murina* (lamponidae) and the cosmopolitan linyphiid *Ostearius melanopygius*.

Aphids (*Myzus* sp.) were abundant on the Kermadec ngaio, their numbers sufficiently high that big-headed ants (*Pheidole megacephala*) were tending to the aphids' honey dew production. Of the diptera, the Kermadec blowfly (*Calliphora kermadeca*) and mosquitoes (*Opifex fuscus*) were also frequent. Less common were several gall flies (*Fergusonina* sp.: fergusonidae), and

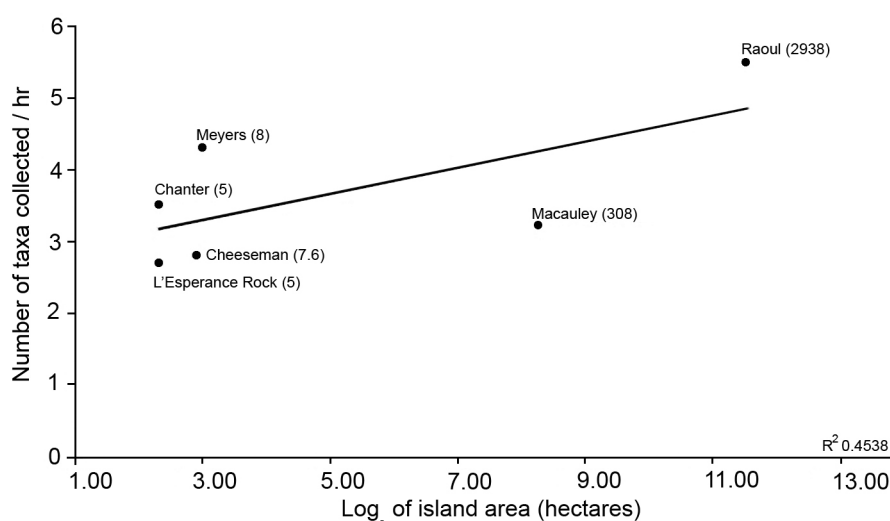


Figure 3. Species/area graph for invertebrates collected from the Kermadec Islands during the May 2011 expedition. The Meyers and Chanter Islands are within five km of Raoul Island. The X-axis values are hectares expressed as logarithms to the base 2.

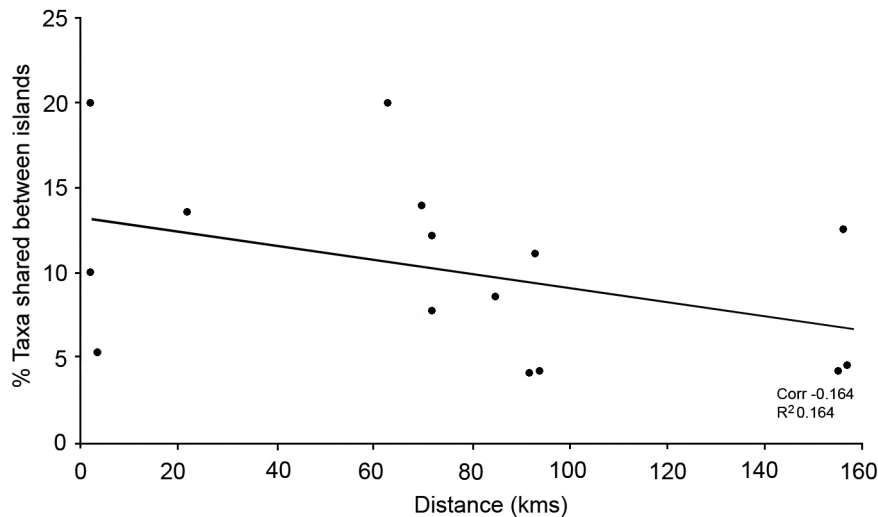


Figure 4. Species/area graph for invertebrates collected from the Kermadec Islands during the May 2011 expedition. The Meyers and Chanter Islands are within five km of Raoul Island. The X-axis values are hectares expressed as logarithms to the base 2.

an indeterminate species of dung fly (spaeroceridae). Orthoptera were represented by the ubiquitous cricket *Ornebius kermadecensis*, while the most abundant coleopteran on the Meyers Islands was Fuller's rose weevil (*Asynonychus cervinus*) collected from Kermadec ngaio and no doubt introduced through farming and horticultural activities on nearby Raoul Island.

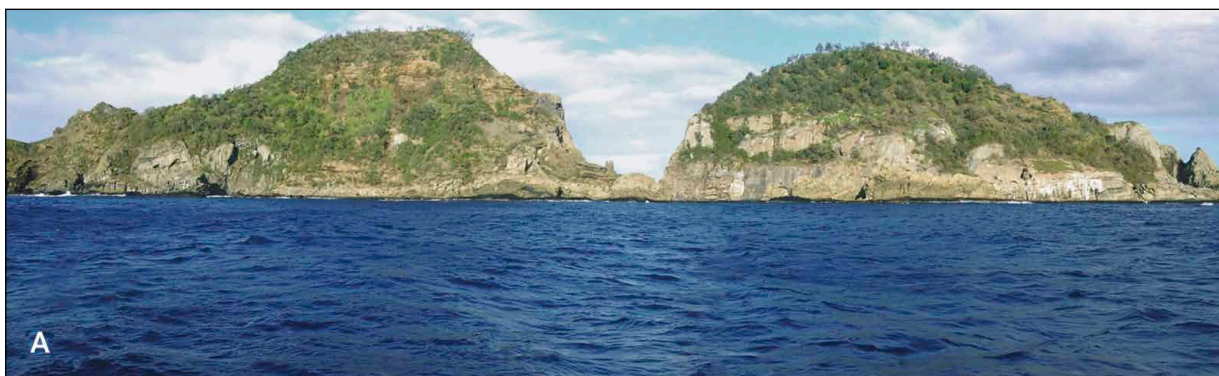
North Chanter Island

North Chanter is an uplifted coral bed (a 'makatea') with a basalt basement (Fig. 5B, C). The vegetation is sparse and includes the New Zealand fern *Asplenium northlandicum*, ice plants *Disphyma australe* subsp. *stricticaule*, introduced purslane *Portulaca oleracea* and two nightshades *Solanum nigrum* and *S. nodiflorum*. At the time of our visit, however, the vegetation on the island had been severely stripped by cyclone Bune in March 2011, leaving remnant Kermadec ngaio shrubs on the summit of the island and these plants were host to many aphids (*Myzus* sp.) and attendant big-headed ants. Hemiptera were common amongst all vegetation types, including plant hoppers *Cermada* sp. and the Lygaeid *Remaudiereana inornata*, which is shared with Raoul and Macauley Islands. The blow fly *Calliphora kermadecensis* was also common, associated with bird nesting sites. The

habitat was otherwise composed of skeletal soils and crevices within the coral beds, and these were occupied by silver fish *Lepisma* sp. Overall, the depauperate terrestrial arthropod fauna of North Chanter reflects the minimal surface area, high soil disturbance regime and often catastrophic weather conditions, conditions suitable for transient and opportunistic flying insects.

Macauley Island

The ecology of Macauley Island is profoundly simpler than that of Raoul Island, consisting of a deep bracken *Hypolepis dicksonioides* fernland and strips of *Cyperus insularis* sedgeland (Fig. 5D) (see also de Lange 2015a). Goats have significantly modified the vegetation to the extent that woody species on Macauley Island are now restricted to Kermadec ngaio in scattered stands on the summit ridge of the Island's crater and a single specimen of the endemic Kermadec poplar (*Homolanthus polyandrus*). The poplar tree was found in 2006 by four members of the DOC parakeet survey team and was reported as a "multi-leadered tree [with] long decumbent branches arising from a short trunk, 1.03 m in diameter," with an estimated canopy diameter of 17 m (Barkla *et al.* 2008). During our visit however, the tree had died though it had also produced numerous



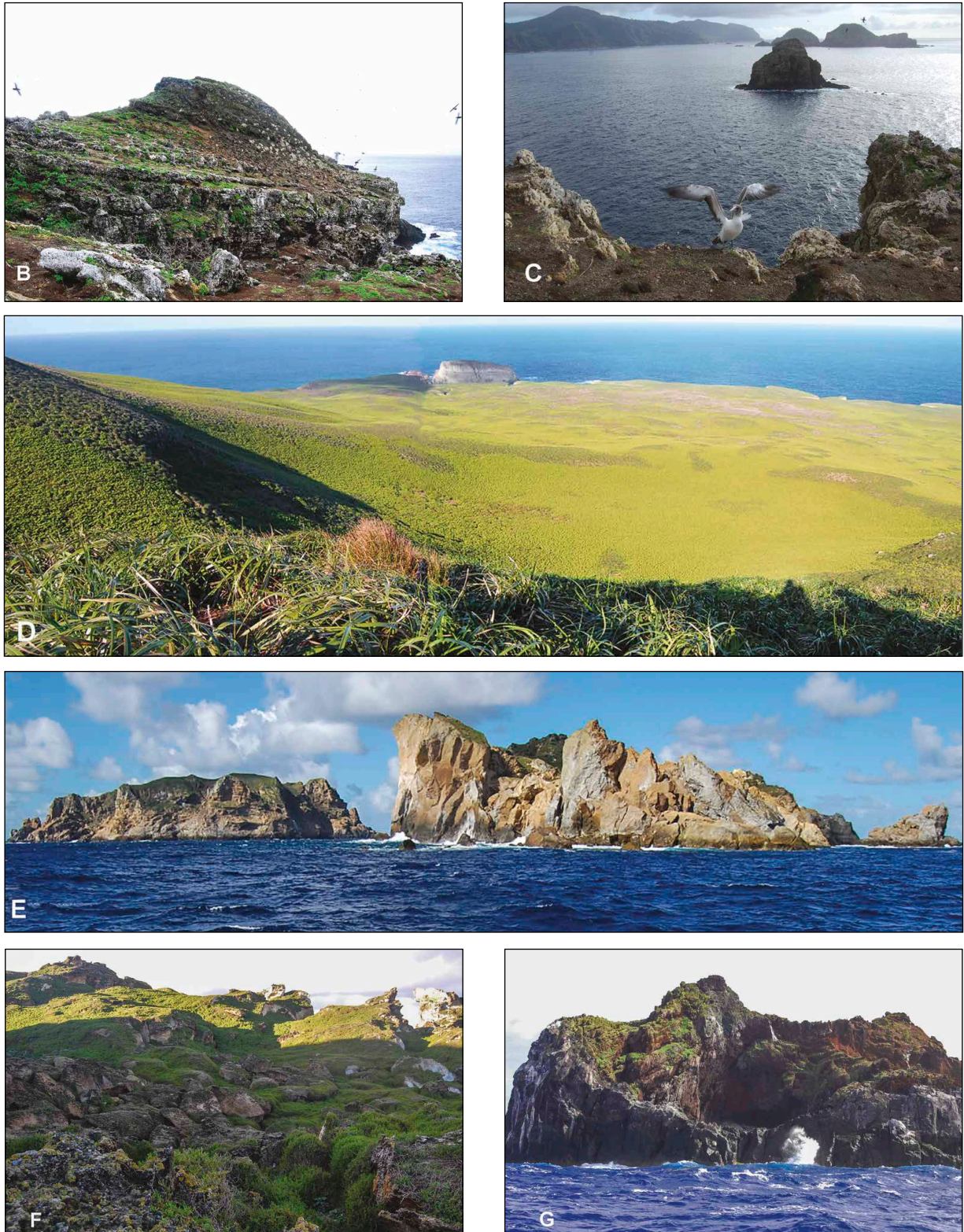


Figure 5. Photographs showing some of the outlying Kermadec Islands. **A.** The Meyers, North (left) and South (right), view looking southeast with open ngaio and pōhutukawa forest visible on slopes. **B.** North Chanter Island showing makatea (uplifted coral beds) and the ice plant *Disphyma australe* subsp. *stricticaule*. **C.** View from North Chanter looking west across West Chanter, toward the Meyer Islands. Raoul Island at rear left with a masked booby in the foreground. **D.** Macauley Island, view toward southeast into the main crater. *Cyperus insularis* dominates the ground cover. Haszard Islet is visible at centre rear, displaying the layered pyroclastics. **E.** Curtis Island (left) and Cheeseman Island (right). Landfall was made from far right side of Cheeseman Island. **F.** Habitat and vegetation on Cheeseman Island. The ice plant *Disphyma australe* subsp. *stricticaule* is dominant in this view with *Cyperus insularis* on slopes at rear. **G.** L'Esperance Rock. View northwest into the main crater. Access was from the north via a shallow lava gully. Note elevation above sea level of the (limited) vegetation and the extent of guano encrusting any bluff not in surge zones.

saplings growing up to 10 m from, and peripheral to, the original canopy (de Lange 2015a).

In their Macauley Island parakeet survey report Greene *et al.* (2004) noted the presence of crickets, locusts, spiders, land snails, elaterid beetles, flies, a convolvulus sphinx moth (*Agrius convolvuli*) and the yellow admiral butterfly *Vanessa itea*. During our visit, a number of these taxa were collected or seen and the combined record indicates that the invertebrate ecology of Macauley Island is also simple, consisting of small-bodied forms, capable of aerial dispersal and vagrancy with a trophic hierarchy limited to the detritivores, herbivores and predators. The record of a Sphinx moth on the island is also interesting because it suggests that the moths may fly from Norfolk Island to the Kermadec Islands (Holloway 1982). In general, sphingids are among the fastest and strongest-flying lepidoptera (capable of flying at over 5.3 m/s: Stevenson *et al.* 1995) and the caterpillars may feed on *Solanum* (nightshade), which is present on most of the Kermadec Islands.

Several noteworthy Diptera were collected from the malaise trap (erected beneath the poplar tree canopy). The fly taxa included a scaptomyzid (*scaptomyza* sp.), sciaridae (*Corynoptera* sp.), an unidentified psychodid and the tipulid *Limonia aegrotaens*. These flies were active during the installation of the trap, flying in close proximity to the ground above a catacomb of burrows made by the white napped petrel (*Pterodroma cervicalis*).

Macauley Island coleoptera were represented by widespread Pacific taxa, including the flea beetle *Psylliodes brethinghami*: chrysomelidae, *Pentarthrum gracilicorne* (cossinidae), *Didymus metrosideri* (curculionidae), *Conoderus exsul* (elateridae) and *Notolinussocius* (staphylinidae). *Ornebius kermadecensis* and the common locust (*Locusta migratoria*) were similarly common, in varying stages of development. The high-pitched chirping of *O. kermadecensis* was audible throughout the island, attenuating at nightfall. Australasian spiders were also very common in almost all locations searched and species included: *Leucauge dromedaria* (tetragnathidae), the ubiquitous orb-weaver *Eriophora pustulosa* (araneidae), *Bianor maculatus* (salticidae), *Hogna crispipes* (lycosidae) and the common *Clubiona cada* (clubionidae).

Cheeseman Island

Cheeseman and Curtis Islands are the twin summits of an andesite volcanic massif, separated by the narrow (570 m) Stella Passage. Cheeseman Island has steep inaccessible bluffs on the southern aspect while the northern terrain is gently concaved, sloping no more than 15 degrees and surrounded by fractured tors, blocks and columns (Fig. 5E, F). Again, vegetation is confined to thin soils on the north-eastern aspect of the island and consists (in part) of *Cyperus insularis* sedgeland and ice plant (*Disphyma australe* subsp. *stricticaule*) turf, through which the Kermadec Island endemic scurvy grass *Lepidium castellanum* and the nightshade *Solanum nodiflorum* were occasionally noted (de Lange 2015b).

Diptera were common on Cheeseman Island, particularly salt mosquitoes *Opifex fusca* which,

during our visit, were abundant at a small brine pool approximately 10 m from the ocean and at a similar height above sea level. The pool water was probably thrown up during storms as a briny mix of sea spray and rain. Associated with the many petrel burrows was a Fannid fly (*Fannia* sp.) and while relatively common is possibly endemic to the Kermadec Islands and potentially a new species (R. Macfarlane 2012 pers. comm.). A single specimen of the chrysomelid *Psylliodes brethinghami* was collected from the foliage of a nightshade, establishing a new location record for this Melanesian-wide species (Samuelson 1973).

L'Esperance Rock

Remote L'Esperance Rock presents a striking feature against the isolation of the ocean (Fig. 5G). Soils are minimal (if not skeletal) and comprise oxidised basalt and tephra, enriched with guano, salt and decaying vegetation. Under these conditions, the northern shore spleenwort (*Asplenium northlandicum*), the endemic L'Esperance Rock groundsel (*Senecio. lautus* subsp. *esperensis*), ruderals and lichens were identified during our visit (de Lange 2015c). Insects on L'Esperance Rock were limited to diptera (the ephydrid *Scatella nitidifrons* and the mosquito *Opifex fuscus*), the cosmopolitan thysanuran *Lepisma saccharina* and the cricket *Ornebius kermadecensis*. The latter were collected from near the summit of L'Esperance Rock and seldom found elsewhere.

Arachnids from L'Esperance Rock included pseudoscorpions (possibly *Protochelifer* sp. - found beneath basaltic stones and amongst the loose, friable soil), a lycosid *Hogna crispipes* and numerous red trombidiform mites (*Neomolgus* sp.), the latter confined entirely to intertidal rocks (additional identification work is required on these specimens). The bird tick *Ixodes amersoni* was collected from petrel carcasses, and several of these birds appeared to have been recently killed, possibly by a harrier (*Circus approximans*, G. Taylor pers. comm.). Alternatively, parakeets are known to kill other birds and may make long-distance excursions to L'Esperance Rock, preying on the petrels. The phenomenon has been observed in Antipodes parakeets *Cyanoramphus unicolor* on the Antipodes Islands. These parakeets can kill and feed on grey-backed storm petrels *Oceanites nereis* (A. Grant pers. comm. and see Greene 1999).

DISCUSSION

Taxonomic composition of the islands

This work adds 12 potentially new species records to the known Kermadec Island fauna (largely flies) and at this stage it seems unlikely these taxa are endemic to the Kermadec Islands, given that the majority of the fauna comprises known types with efficient dispersal abilities. Furthermore, most of the known endemics tend to be flightless forms inhabiting the soil and litter of Raoul Island's forests. There were 47 new location records, primarily from the outlying islands, an expected outcome given the infrequency of human visits and collection effort at the locations.

The results of this survey are consistent with Watt's synopsis that the terrestrial invertebrate fauna of the Kermadec Islands is depauperate and fragmentary (Watt 1975a). While several taxa from this survey are endemic (an earthworm, a centipede and snails), the majority are found elsewhere in the South Pacific and even the snail fauna, which have affinities to New Zealand and Tonga, remain scant due to the isolation and comparatively young age of the Kermadec Islands (F. Brook 2012 pers. comm.).

All of the Kermadec Islands are significant bird habitats supporting masked boobies (*Sula dactylatra tasmani*), Kermadec petrels, red tailed tropic birds, shearwaters (*Puffinus pacificus*) and Kermadec Island parakeets amongst the permanent residents. The birds undoubtedly transport invertebrates between islands and are themselves significant habitats for a rich diversity of parasites. Following the 1967 New Zealand Ornithological Society expedition, Charles Watt reported on the ectoparasites from birds and mammals on Meyer and Raoul Islands, and included a species key to the flies, fleas and lice (Watt 1972). Watt collected 60 species, of which 42 were new records, and when contrasted with the land taxa, this suggests that arthropod endemism (as it is) may be skewed toward bird parasites rather than terrestrial types, at least to the extent that genetic drift in isolation and adaptive radiation has probably not had sufficient time to manifest.

Similarly, the observed decrease in the number of taxonomic classes between Raoul Island and L'Esperance Rock is (among other things) likely to be coupled with a reduction in habitat complexity. The soils on Raoul Island comprise deep volcanic oxides with a rich organic layer. By contrast, Macauley Island soils are considerably thinner, drier and extensively disturbed by petrel bioturbation and this may contribute to the apparent lack of centipedes, millipedes and worms. On Cheeseman Island the disturbance is accentuated because soils are no deeper than 200 mm (at best) and terrestrial molluscs also appear to be absent in the fauna. L'Esperance Rock scarcely has any soils at all and very limited habitat diversity, a situation that seems to have induced a fauna biased toward arachnids, specifically bird ticks, spiders and pseudoscorpions – forms that do not go through metamorphosis and therefore do not require a protracted development time and physically stable environment.

The absence of any clear adaptive radiation is a conspicuous feature of the Kermadec Island fauna. As an evolutionary phenomenon, adaptive radiation is promoted by isolation (allopatry) or by selective pressure operating at time scales of at least 10^4 years and certainly over 10^6 , time spans beyond the current age values given for the Kermadec Islands. This effect is one possible explanation for the close genus-to-species ratio (1:1.07), and is consistent with a fauna whose members comprise numerous founder taxa. An alternative (or tandem) possibility is interspecific competition where ecological resources are required equally between congeners and where, as island area decreases, competition increases, driving the genus-to-species ratio down or even to unity (Peck *et al.* 1999; Fattorini 2009).

Biogeography

Species-area relationships

Species diversity on islands increases proportionately with land area (Preston 1948; 1960; Williams 1964; MacArthur 1972; Simberloff 1974; Williamson 1981; 1988; Rosenzweig 1995), and the Kermadec Islands are no exception. The species-area relationship presented in this work conforms to the classical theory of island biogeography (that is, species richness is proportionally lower on smaller islands and there is a balance between extinction and immigration) (MacArthur & Wilson 1967).

Invertebrate immigration on the Kermadec Islands occurs via 'water, wind or wings' and more recently, via human activity - a mode that biases the background species/area relationship. Comparative studies of species area curves for New Zealand's other remote islands are rare. However, Williams (1982) carried out a literature-based species-area study of insects and plants on seven of New Zealand's southern islands including; Chatham (965 km²), Auckland (612), Macquarie (Australian) (118), Campbell (114), Antipodes (21), Snares (2.8) and the Bounty Islands (1.3). Although the area of these islands is significantly larger than the Kermadec Islands, they are of equivalent isolation. Williams produced a species area curve with an *r* value of 0.738 (*n*=7 islands), using a species/log area plot (Williams 1982). The equivalent analysis for this work generated an *r* value of 0.454 (*n*=6 islands), in both cases the differences are a function of at least three effects including; larger area (several orders of magnitude), wider geological age range (0.5–25 m.y.) (Adams 1981) and, in the case of the Chatham Islands, close proximity to the substantial biological reservoir effect of the South Island.

Another significant attribute of the Kermadec Islands is the potential for testing ecological theories. Community resilience is a particular case, where the smaller Kermadec Islands may be ecologically unstable in the absence of continuous immigration (and their low species diversity) while grading toward increased stability on the larger islands. This could be due to a scalar increase of species diversity (and therefore complex guilds and hierarchies) and landscape heterogeneity which facilitates ecological resistance against catastrophic disturbances (Holling 1973; Lomolino 2000; Gunderson 2000; Peterson *et al.* 1998; Folke *et al.* 2004;). To that extent, ecological resilience within the Kermadec Islands may, in fact, describe a logistic function (sigmoid curve) with resilience on the ordinate and island area on the abscissa.

Invertebrate exchange among the islands and between old faunas

This work found an inverse relationship between taxa shared among the islands and geographic distance (*r*² -0.164), suggesting that most of the islands exchange vagile taxa but that distance is possibly less significant to the island fauna than is habitat suitability. That is, for many groups the diversity of habitats between the islands may be a larger impediment to colonisation than crossing the ocean, the resultant effect being an ecological filter. The outcome of this could be differential survival of

many taxonomic groups on a few islands but with complete colonisation of a few select taxa on all islands. Perhaps of highest significance was the apparent lack of big headed ants on Macauley and Cheeseman Islands and L'Esperance Rock. This is a crucial finding because it means the current fauna are intact and probably a close analogue of the pre-human biota.

The island relatives of many New Zealand invertebrates apparently dispersed during the Pleistocene, a time when land bridges and island 'stepping stones' were present. Good examples include the genus *Pseudhelops*, coleoptera: tenebrionidae from the Sub-Antarctic Islands (Leschen *et al.* 2011), and several flightless insects from the Chathams Islands (Goldberg & Trewick 2011). However, unlike the Chatham and Sub Antarctic Islands, the Kermadec Islands were never geologically part of New Zealand and have a separate geological history (Latter *et al.* 2010). To that extent, a notable feature of the Kermadec Island fauna is the sampling effect of oceanic isolation and the young geochemical history, both are features that offer a datum from which to make observations on invasion, natural immigration, extinction and ecosystem function between the islands. These opportunities contrast with the phylogeographic studies available for the Sub-Antarctic group.

Although the nearest land masses to the Kermadec Islands are New Zealand (Northland is 800 km southwest), followed by Tonga (917 km north) and Norfolk Island (1376 km nearly due west), their relatively small distances allow cyclonic systems to cross either from the Tasman or as tropical storms moving southeast past Tonga and certainly deliver live invertebrates in various life stages. An interesting example of this is the distribution of *Ornebius kermadecensis*, a flightless mogoplistine cricket, found on all the islands visited and which is unlikely to be endemic (P. Johns 2011 pers. comm.). *Ornebius* crickets appear to have dispersed throughout the southwest Pacific, often dominating the insect fauna and they are well represented, for example, on Norfolk Island (Rentz 1988), New Caledonia (Otte *et al.* 1987) and Lord Howe Island (Otte & Rentz 1985). The ocean dispersal method is probably through eggs deposited in wood etc, floating between islands (Otte *et al.* 1987). These findings might also offer an additional challenge to the notion that vicariance was the prime mover of life in the South Pacific (Craw 1989), while supporting Didham's observation that New Zealand (and outer islands) are the "fly paper of the Pacific" (Didham 2005).

CONCLUSIONS

As a chain of subtropical islands, the Kermadec Islands experience trade winds and westerly moving ocean gyres. Raoul Island is located within these global systems and is sufficiently large in space, persistent in time and with enough ecosystem heterogeneity for some endemism to arise (particularly amongst

ground-dwelling forest taxa, suggesting that this habitat, at least, is stable). Raoul Island's coastline and land area are also extensive enough for continuous random immigration to effectively balance chance extinction. However, the absence of large, flightless invertebrates on the Kermadec Islands (for example, tree weta, carabid beetles, tunnel web spiders and heavy carnivorous snails) is, in the first instance, due to isolation and size. Human-introduced pests (rats, cats, birds and hedgehogs?), no doubt had an impact on the invertebrate fauna and may have driven any large-bodied taxa to extinction (although evidence for 'hopeful monsters' is sorely lacking). Blackbirds *Turdus merula* remain on Raoul Island and are probably still having an impact on the small suite of indigenous fauna.

Observation suggests that an ecological filtering effect occurs between the islands and is a function of habitat heterogeneity, island size and human-induced ecological change. This finding has implications for conservation, and an understanding of the community structure on the islands is necessary for management. It is probably crucial that some form of ecological monitoring, using a selection of indicator taxa (plant and invertebrate), be considered for the terrestrial environments of the Kermadec Islands. Furthermore, the Kermadec Islands present more than a model of island biogeographic theory; they also present some tantalising resource partitioning patterns and offer a datum against which we can compare the effects of human activities globally.

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Warren G.H. Chinn, Department of Conservation, Private Bag 4715 Christchurch, New Zealand. Email: wchinn@doc.govt.nz
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APPENDIX: (Starts adjacent page) **List of invertebrates collected from the Kermadec Islands, during the May 2011 Auckland Museum biodiversity expedition.**

PR=Previous Record, NR=New Record, NS=New Species

CLASS: ORDER FAMILY	Taxon	Location	Latitude / longitude	Collection date	Collection status		
					PR	NR	NS
ANNELIDA: CLITELLATA							
	LUMBRICIDAE	<i>Megascolecidae laingii</i> Benham, 1903	Raoul Is. Mounoukai summit	S29°16'02.30"W177°54'28.40"	May 12, 2012	✓	
		<i>Allolobophora caliginosa</i> Savigny, 1826	Nth. Meyer Is.	S29°14'40.13"W177°54'28.40"	May 12, 2012	✓	
			Raoul Is. Sunshine Bay	S29°18'50.00" W177°54'50.00"	May 12, 2012	✓	
			Raoul Is. Mounoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011	✓	
ARACHNIDA: ACARI							
	IXODIDAE	<i>Ixodes amersoni</i> Kohls, 1966	L'Esperance Rock	S31°26'00.00"W178°54'00.00"	May 26, 2011		✓
	BDELLIDAE	<i>Neomolgus</i> sp.	L'Esperance Rock, intertidal rocks	S31°26'00.00"W178°54'00.00"	May 26, 2011		✓
ARACHNIDA: PSEUDOSCORPIONIDA							
	CHELIFERIDAE	<i>Protochelifer</i> sp.	L'Esperance Rock	S31°26'00.00"W178°54'00.00"	May 26, 2011		✓
ARACHNIDA: ARANEAE							
	ARANEIDAE	<i>Eriophora pustulosa</i> (Walckenaer, 1841)	Raoul Is. Denham Bay	S29°26'12.80"W177°56'16.10"	May 18, 2011	✓	
			Raoul Is. Met Station	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓	
			Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011	✓	
			Raoul Is. Mounoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011	✓	
			Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011		✓
			Sth Meyer Is.	S29°14'49.84"W177°52'43.68"	May 13, 2011	✓	
CLUBIONIDAE		<i>Clubiona cada</i> Forster, 1979	Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011		✓
			Raoul Is. Mounoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011		✓
			Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011		✓
			Raoul Is. Airstrip	S29°14'36.11"W177°56'16.00"	May 17, 2011		✓
DESIDAE		<i>Hulua</i> undescribed species	Raoul Is. Mounoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011		✓
		<i>Badumna longinqua</i> (L. Koch, 1867)	Raoul Is. Egeria Rock	S29°14'59.52"W177°53'42.10"	May 13, 2011		✓
			Raoul Is. Met station	S29°14'36.10"W177°56'16.10"	May 17, 2011	✓	
LAMPONIDAE		<i>Lampona murina</i> L. Koch, 1893	Sth Meyer Is.	S29°14'49.84"W177°52'43.68"	May 13, 2011	✓	
			Raoul Is. Airstrip	S29°14'36.11"W177°56'16.50"	May 13, 2011	✓	
LINYPHIIDAE	<i>Laetesia peramoena</i> (O.Pickard-Cambridge, 1879)	Raoul Is. Mounoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011			✓

CLASS: ORDER FAMILY	Taxon	Location	Latitude / longitude	Collection date	Collection status		
					PR	NR	NS
LYCOSIDAE	<i>Ostearius melanopygius</i> (O. Pickard-Cambridge, 1879)	Sth Meyer Is.	S29°14'49.84"W177°52'43.68"	May 13, 2011		✓	
	<i>Hogna crispipes</i> (L. Koch, 1877)	Raoul Is. Denham Bay	S29°26'12.80"W177°56'16.10"	May 18, 2011	✓		
		L'Esperance Rock	S31°26'00.00"W178°54'00.00"	May 26, 2011		✓	
		Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011		✓	
		Cheeseman Is.	S30°32'16.10"W178°33'59.90"	May 24, 2011		✓	
		Macauley Is.	S30°13'48.10"W178°25'27.30"	May 26, 2011		✓	
	<i>Bianor maculatus</i> (Keyserling, 1883)	Raoul Is. Denham Bay	S29°15'42.50"W177°56'48.00"	May 18, 2011		✓	
	<i>Hypoblemum albovittatum</i> (Keyserling, 1882)	Raoul Is. Mounmoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011		✓	
		Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011		✓	
	<i>Helpis minitabunda</i> (L. Koch, 1880)	Raoul Is. Airstrip	S29°14'36.11"W177°56'16.50"	May 17, 2011		✓	
	<i>Stiphidion facetum</i> Simon, 1902	Raoul Is. Mounmoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011		✓	
	<i>Tetragnatha nitens</i> Audouin, 1826	Raoul Is. Denham Bay	S29°26'12.80"W177°56'16.10"	May 18, 2011		✓	
	<i>Leucauge dromedaria</i> (Thorell, 1881)	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011		✓	
		Raoul Is. Mounmoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011		✓	
		Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011		✓	
	<i>Cryptachaea blattea</i> (Urquhart, 1886)	Raoul Is. Mounmoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011		✓	
THERIDIIDAE	<i>Cryptachaea veruculata</i> (Urquhart, 1886)	Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011		✓	
	<i>Steatoda grossa</i> (Koch, 1838)	Raoul Is. Sunshine Bay	S29°18'50.00"W177°54'50.00"	May 16, 2011		✓	
		Macauley Is.	S30°13'57.70"W178°26'07.40"	May 21, 2011		✓	
		Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011		✓	
		Raoul Is. Mounmoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011		✓	
CHILOPODA: LITHOBIOMORPHA							
	<i>Lamycetes emarginatus</i> Newport, 1844	Raoul Is. Mounmoukai track	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
	<i>Lamycetes kermadecensis</i> Archey, 1917	Raoul Is. Mounmoukai track	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
	<i>Lithobius cf. forficatus</i> Linnaeus, 1758	Raoul Is. Mounmoukai track	S29°16'02.30"W177°54'28.40"	May 14, 2011		✓	
SCOLOPENDRAMORPHA CRYPTOPTIDAE	<i>Cryptops</i> sp.	Raoul Is. Mounmoukai track	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		

CLASS: ORDER		Taxon	Location	Latitude / longitude	Collection date	Collection status		
FAMILY						PR	NR	NS
DIPLOPODA: JULIDA								
BLANIULIDAE JULIDAE	<i>Blaniulus guttulatus</i> Fabricius, 1798	Raoul Is. Mounoukai track	S29°16'02.30"W177°54'28.40"	May 14, 2011		✓		
	<i>Cylindroiulus britannicus</i> Verhoeff, 1891	Raoul Is. Mounoukai track	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓			
INSECTA: BLATTODEA								
BLATTIDAE	<i>Celatoblatta undulivitta</i> Johns, 1967	Raoul Is. Denham Bay hut	S29°26'12.80"W177°94'57.71"	May 18, 2011	✓			
	<i>Drymaplaneta semivitta</i> Walker, 1868	Raoul Is. Met. Stn.	S29°14'36.10"W177°56'16.10"	May 18, 2011	✓			
	<i>Periplaneta americana</i> Linnaeus, 1758	Raoul Is. Denham Bay hut	S29°26'12.80"W177°94'57.71"	May 18, 2011	✓			
	<i>Periplaneta fuliginosa</i> Serville, 1838	Raoul Is. Denham Bay hut	S29°26'12.80"W177°94'57.71"	May 18, 2011	✓			
						✓		
INSECTA: COLEOPTERA								
CARABIDAE	<i>Notogonum marginellum</i> (Erichson, 1842)	Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011		✓		
CHRYSOMELIDAE	<i>Psylliodes bretinghami</i> Baly, 1862	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011	✓			
		Raoul Is. Mounoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011				
		Cheeseman Is.	S30°32'16.60"W178°33'59.90"	May 24, 2011		✓		
COSSINIDAE	<i>Pentarthrum gracilicorne</i> Broun, 1910	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 17, 2011	✓			
CURCULIONIDAE		Macauley Is.	S30°13'48.10"W178°25'27.30"	May 23, 2011				
	<i>Asynonychus cervinus</i> Boheman, 1840	Nth Meyer Is.	S29°14'42.20"W177°52'35.50"	May 20, 2011	✓			
	<i>Didymus metrosideri</i> Broun, 1910	Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011	✓			
		Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011				
	<i>Peniticus wallacei</i> Broun, 1910	Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011	✓			
ELATERIDAE	<i>Crossotarsus externedentatus</i> Fairmaire, 1850	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 17, 2011	✓			
SILVANIDAE	<i>Conoderus exsul</i> Sharp, 1877	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011	✓			
	<i>Cryptamorpha desjardinsi</i> Guérin-Meneville, 1844	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 17, 2011	✓			
	<i>Notolinus socius</i> Fauvel, 1877	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011	✓			
STAPHYLINIDAE								
INSECTA: DERMAPTERA								
ANISOLABIDIDAE	<i>Euborellia annulipes</i> Lucas (1847)	Raoul Is. Denham Bay hut	29° 26'12.80"W177° 94'57.71"	May 17, 2011		✓		

CLASS: ORDER FAMILY	Taxon	Location	Latitude / longitude	Collection date	Collection status		
					PR	NR	NS
INSECTA: DIPTERA CALLIPHORIDAE	<i>Calliphora kermadeca</i> Kurahashi, 1971	Raoul Is.	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
		Sth Meyer Is.	S29°14'49.84"W177°52'43.68"	May 12, 2011	✓		
		Raoul Is. Denham Bay hut	S29°26'12.80"W177°94'57.71"	May 18, 2011	✓		
		Nth Chanter Is.	S29°14'30.00"W177°50'80.00"	May 16, 2011		✓	
CERATOPOGONIDAE	<i>Paradasyhelea egraria</i> Macfie, 1932	Raoul Is. Moumoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
	<i>Paradasyhelea</i> sp.	Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011			?
		Raoul Is. Moumoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011			?
CHLOROPIDAE CULICIDAE	<i>Conioscinella badia</i> Hutton, 1901	Raoul Is. Moumoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011	✓		
	<i>Opifex fuscus</i> Hutton, 1902	Sth Meyer Is. (Ex. ship at anchor)	S29°14'49.84"W177°52'43.68"	May 12, 2011	✓		
		Cheeseman Is.	S30°32'16.60"W178°33'59.90"	May 24, 2011	✓		
		L'Esperance Rock	S31°26'00.00"W178°54'00.00"	May 26, 2011	✓		
DOLICHOPODIDAE DROSOPHILIDAE EPHYDRIDAE	<i>Achalcus</i> sp.	Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011	✓		
	<i>Scaptomyza flavella</i> ? Harrison, 1959	Cheeseman Is.	S30°32'16.60"W178°33'59.90"	May 24, 2011	✓		
	<i>Hydrellia</i> sp.	Raoul Is. Egeria Rock	S29°14'59.52"W177°53'42.10"	May 13, 2011	✓		
	<i>Neoscatella vittithorax</i> Malloch, 1925	Cheeseman Is.	S30°32'16.60"W178°33'59.90"	May 24, 2011	✓		
FANNIDAE FERGUSONINIDAE MUSCIDAE PHORIDAE PSYCHODIDAE SAPROMYZIDAE	<i>Scatella nitidifrons</i> Cresson, 1918	L'Esperance Rock	S31°26'00.00"W178°54'00.00"	May 26, 2011	✓		
	<i>Fannia</i> sp.	Cheeseman Is.	S30°32'16.60"W178°33'59.90"	May 24, 2011	✓		?
	<i>Fergusonina</i> sp.	Sth Meyer Is.	S29°14'49.08"W177°52'43.12"	May 13, 2011	✓		
	<i>Atherigona</i> sp.	Raoul Is. Moumoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011	✓	shared	
SARCOPHAGIDAE SCAPTOMYZIDAE SCIARIDAE	<i>Megaselia</i> sp.	Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011	✓		
	Indet. species	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 23, 2011	✓		?
	<i>Sapromyza similima/dichromata</i> complex Walker, 1849	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 18, 2011	✓		
		Raoul Is. Denham Bay	S29°15'42.50"W177°56'48.00"	May 18, 2011	✓		
SARCOPHAGIDAE SCAPTOMYZIDAE SCIARIDAE		Raoul Is. Sunshine Bay	S29°18'50.00"W177°54'50.00"	May 15, 2011	✓		
	<i>Sarcophaga</i> sp.	Raoul Is. Denham Bay hut	S29°26'12.80"W177°94'57.71"	May 18, 2011	✓		
	<i>Scaptomyza</i> sp.	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 23, 2011	✓		
	<i>Corynoptera</i> sp.	Macauley Is.	S30°13'57.10"W178°25'07.11"	May 23, 2011	✓		

CLASS: ORDER FAMILY	Taxon	Location	Latitude / longitude	Collection date	Collection status		
					PR	NR	NS
SPHAEROCERIDAE SYRPHIDAE TIPULIDAE	Indet. species	Sth Meyer Is.	S29°14'49.08"W 177°52'43.12"	May 13, 2011		✓	
	<i>Simosyrphus grandicornis</i> Macquart, 1842	Raoul Is. Mounoukai summit	S29°16'02.30"W 177°54'28.40"	May 15, 2011	✓		
	<i>Limonia aegrotaens</i> (Edwards)	Macauley Is.	S30°13'48.10"W 178°25'27.30"	May 22, 2011		✓	
	<i>Metalibnotes watti</i> Alexander, 1973	Raoul Is. Denham Bay	S29°15'42.50"W 177°56'48.00"	May 18, 2011	✓		
INSECTA: HEMIPTERA							
APHIDAE	<i>Myzus</i> sp. cf. <i>persicae</i> (Sulzer, 1776)	Sth Meyer Is. Nth Chanter Is.	S29°14'49.08"W 177°52'43.12" S29°14'30.00"W 177°50'80.00"	May 13, 2011 May 16, 2011		✓ ✓	
CIXIIDAE	<i>Cermada kermadecensis</i> Mayers, 1924	Raoul Is. Mounoukai summit	S29°16'02.30"W 177°54'28.40"	May 15, 2011	✓		
COCCIDAE	<i>Cermada</i> sp.	Sth Meyer Is.	S29°24'69.40"W 177°8'80.80"	May 13, 2011	✓		
		Macauley Is.	S30°13'48.10"W 178°25'27.30"	May 22, 2011	✓		
		Nth Chanter Is.	S29°14'30.00"W 177°50'80.00"	May 16, 2011		✓	
	<i>Coccus hesperidum</i> (Linnaeus, 1758)	Raoul Is. Mahoe Hut	S29°18'50.00"W 177°57'00.00"	May 15, 2011	✓		
DELPHACIDAE	<i>Ugyops raouli</i> Muir, 1923	Raoul Is. Airstrip	S29°24'37.96"W 177°93'53.43"	May 13, 2011	✓		
		Raoul Is. Mounoukai summit	S29°16'02.30"W 177°54'28.40"	May 17, 2011	✓		
	<i>Sardia rostrata pluto</i> Kirkaldy, 1906	Macauley Is. Cheeseman Is.	S30°13'48.10"W 178°25'27.30" S30°32'16.60"W 178°33'59.90"	May 23, 2011 May 24, 2011		✓ ✓	
LYGAEIDAE	<i>Remaudiereana inornata</i> (Walker, 1872)	Raoul Is. Mounoukai summit	S29°16'02.30"W 177°54'28.40"	May 15, 2011	✓		
		Raoul Is. Airstrip	S29°24'37.96"W 177°93'53.43"	May 18, 2011	✓		
		Macauley Is.	S30°13'48.10"W 178°25'27.30"	May 23, 2011	✓		
		Raoul Is. Denham Bay Nth Chanter Is.	S29°15'42.50"W 177°56'48.00" S29°14'30.00"W 177°50'80.00"	May 18, 2011 May 16, 2011		✓ ✓	
GERRIDAE	<i>Halobates sericeus</i> Eschscholtz, 1822	Stella Passage	S30°32'16.00"W 178°33'59.00"	May 23, 2011		✓	
INSECTA: HYMENOPTERA							
APIDAE	<i>Apis mellifera</i> Linnaeus, 1758	Raoul Is. Airstrip	S29°24'37.96" W 177°93'53.43"	May 13, 2011		✓	

CLASS: ORDER FAMILY	Taxon	Location	Latitude / longitude	Collection date	Collection status		
					PR	NR	NS
FORMICIDAE	<i>Pheidole megacephala</i> (Fabricius, 1793)	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 13, 2011	✓		
		Raoul Is. Mounoukai summit	S29°16'02.30"W177°54'28.40"	May 15, 2011	✓		
		Raoul Is. Woolshed Hut	S29°24'37.95"W177°93'06.65"	May 17, 2011	✓		
		Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 18, 2011	✓		
		Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011	✓		
		Nth Meyer Is.	S29°14'42.20"W177°52'35.50"	May 18, 2011	✓		
		Sth Meyer Is.	S29°24'69.40"W177°87'80.80"	May 13, 2011	✓		
		Nth Chanter Is.	S29°14'30.00"W177°50'80.00"	May 16, 2011		✓	
		Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 13, 2011	✓		
		Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 13, 2011	✓		
ICHNEUMONIDAE	<i>Enicospilus</i> sp.	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 13, 2011	✓		
	<i>Ichneumon promissorius</i> Erichson, 1842	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 13, 2011	✓		
	<i>Lissopimpla excelsa</i> (Costa, 1864)	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 13, 2011	✓		
INSECTA: LEPIDOPTERA							
GRAMBIDAE	<i>Spoladea recurvalis</i> Fabricius, 1775	Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011	✓		
	<i>Hydrillodes surata</i> Meyrick, 1910	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
EREBIDAE		Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 17, 2011	✓		
		Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011	✓		
	<i>Hypocala deflorata</i> sub sp. <i>australiae</i> Butler, 1892	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
NOCTUIDAE	<i>Mocis frugalis</i> Fabricius, 1775	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
		Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011	✓		
	<i>Callopietria maillardi</i> Guenee, 1862	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
	<i>Chrysodeixis eriosoma</i> Doubleday, 1843	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
	<i>Leucania stenographa</i> Lower, 1900	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
	<i>Leucocosmia nonagrica</i> Walker, 1864	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
	<i>Spodoptera litura</i> Fabricius, 1775	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
	<i>Tiracola plagiata</i> Walker, 1857	Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
	<i>Yanessa itea</i> Fabricius, 1775	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 23, 2011	✓		
	<i>Endotricha mesenterialis</i> Walker, 1859	Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011	✓		
NYMPHALIDAE							
PYRALIDAE							

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INSECTA: ODONATA							
COENAGRIIDAE	<i>Ishmura aurora aurora</i> Brauer, 1865	Raoul Is. Hostel road	S29°14'36.10"W177°56'16.10"	May 17, 2011	✓		
LIBELLULIDAE	<i>Hemicordulia australiae</i> Rambur, 1842	Raoul Is. Hostel road	S29°14'36.10"W177°56'16.10"	May 17, 2011	✓		
INSECTA: ORTHOPTERA							
ACRIDIDAE	<i>Locusta migratoria</i> Linnaeus, 1758	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 23, 2011	✓		
GRYLLIDAE	<i>Ornebius kermadecensis</i>	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 13, 2011	✓		
		Macauley Is.	S30°13'48.10"W178°25'27.30"	May 23, 2011		✓	
		Cheeseman Is.	S30°32'16.10"W178°33'59.90"	May 24, 2011		✓	
		Nth Chanter Is.	S29°14'30.00"W177°50'80.00"	May 16, 2011		✓	
		L'Esperance Rock	S31°26'00.00"W178°54'00.00"	May 26, 2011		✓	
	<i>Ornebius</i> sp.	Raoul Is. Airstrip	S29°14'36.11"W177°56'16.50"	May 13, 2011	✓		
	<i>Metioche</i> sp.	Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 17, 2011	✓		
	<i>Bobilla</i> sp.	Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 17, 2011	✓		
	<i>Teleogryllus commodus</i> Walker, 1869	Raoul Is. Airstrip	S30°13'57.70"W178°26'07.40"	May 13, 2011	✓		
		Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 17, 2011			
TETTIGONIIDAE	<i>Conocephalus</i> sp. A (nymph)	Raoul Is. Mahoe Hut	S29°18'50.00"W177°57'00.00"	May 15, 2011	✓		
	<i>Conocephalus</i> sp. B (nymph)	Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 17, 2011	✓		
INSECTA: THYSANURA							
LEPISMATIDAE	<i>Lepisma saccharina</i> (Linnaeus 1758)	Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 17, 2011	✓		
		Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 13, 2011	✓		
		Macauley Is.	S30°13'48.10"W178°25'27.30"	May 23, 2011		✓	
		Cheeseman Is.	S30°32'16.10"W178°33'59.90"	May 24, 2011		✓	
		Nth Chanter Is.	S29°14'30.00"W177°50'80.00"	May 16, 2011		✓	
		L'Esperance Rock	S31°26'00.00"W178°54'00.00"	May 26, 2011		✓	
INSECTA: TRICOPTERA							
CHATHAMIIDAE	<i>Philanisus fasciatus</i> Riek, 1977	Raoul Is. Egeria Rock	S29°14'59.52"W177°53'42.10"	May 13, 2011	✓		

CLASS: ORDER FAMILY	Taxon	Location	Latitude / longitude	Collection date	Collection status		
					PR	NR	NS
MALACOSTRACA: ISOPODA ARMADILLIDIIDAE	<i>Armadillidium</i> cf. <i>vulgare</i> Latrielle, 1804	Raoul Is. Moutmoukai track	S29°16'02.30"W177°54'28.40"	May 5, 2011	✓		
		Macauley Is.	S30°13'48.10"W178°25'27.30"	May 23, 2011		✓	
		Cheeseman Is.	S30°32'16.10"W178°33'59.90"	May 24, 2011		✓	
		L'Esperance Rock	S31°26'00.00"W178°54'00.00"	May 26, 2011		✓	
PORCELLIONIDAE	<i>Porcello scaber</i> Latrielle, 1804	Raoul Is. Moutmoukai track	S29°16'02.30"W177°54'28.40"	May 5, 2011	✓		
		Raoul Is. Hostel	S29°14'36.10"W177°56'16.10"	May 15, 2011	✓		
MOLLUSCA: CEPHALOPODA SPIRULIDAE	<i>Spirula spirula</i> (Linnaeus, 1758)	Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 18, 2011	✓		
		Cheeseman Is.	S30°32'16.10"W178°33'59.90"	May 24, 2011		✓	
MOLLUSCA: GASTROPODA ACHATINELLIDAE	<i>Tornatellides subperforatus</i> sub. sp. <i>kermadecensis</i> Pilsbry & Cooke, 1915	Raoul Is. Airstrip	S29°24'37.96"W177°93'53.43"	May 16, 2011	✓		
		Raoul Is. Moutmoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
		Raoul Is. Mahoe Hut	S29°27'92.40"W177°93'65.98"	May 15, 2011	✓		
		Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011	✓		
CHAROPIIDAE	<i>Tornatellinops iredalei</i> Pilsbry & Cooke, 1915	Macauley Is.	S30°13'48.10"W178°25'27.30"	May 22, 2011		✓	
		Raoul Is. Mahoe hut track	S29°18'50.00"W177°51'00.00"	May 15, 2011	✓		
		Raoul Is. Mahoe hut track	S29°18'50.00"W177°51'00.00"	May 15, 2011	✓		
		Raoul Is. Moutmoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
		Raoul Is. Moutmoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
CIONELLIDAE PUNCTIDAE	<i>Cionella lubrica</i> (Müller, 1774)	Raoul Is. Mahoe hut track	S29°18'50.00"W177°51'00.00"	May 15, 2011	✓		
		Raoul Is. Moutmoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
		North Meyer Is.	S29°14'42.20"W177°52'35.50"	May 12, 2011	✓		
		Macauley Is.	S30°13'57.70"W178°26'07.40"	May 22, 2011		✓	
PUPILLIDAE VALLONIIDAE	<i>Pronesopupa senex</i> Iredale, 1913 <i>Vallonia excentrica</i> Sterki, 1893	Raoul Is. Moutmoukai summit	S29°16'02.30"W177°54'28.40"	May 14, 2011	✓		
		Raoul Is. Denham Bay	S29°26'12.80"W177°94'57.71"	May 17, 2011	✓		