AN ECOLOGICAL SURVEY OF SMALL ISLANDS IN THE MERCURY GROUP

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SUMMARY

Three small islands in the Mercury group (Flat Island, Black Rocks and the stack 200 m west of Green Island) were visited in June 1987. An account is given of all vascular plant, bird, lizard and some invertebrate species observed during the brief landings. Short descriptive notes about eight other small islands or stacks in the Mercury group, visited by A.H. Whitaker in 1972, are also included. The biota of the islands visited in June 1987 is compared with other small northern islands. It appears that the islands we visited have escaped direct modification by man, and lack rodents. Some species, e.g. plants such as karo and milk tree; small reptiles, e.g. *Hoplodactylus* spp. and *Leiolopisma* spp.; and seabirds, e.g. diving petrel, are useful indicator species of undisturbed habitats.

INTRODUCTION

The Mercury Islands (Lat. 36° 40'S, Long. 175° 50'E) lie off the north-east coast of the Coromandel Peninsula (Fig. 1). Four of the authors visited this group from 2-10 June 1987 to continue projects on saddlebacks *(Philesturnus carunculatus)* on Stanley Island (TGL) and kiore *(Rattus exulans)* eradication on Korapuki Island (IM). GAT and CMM participated on these projects as volunteers. AHW visited the group in November 1972 as part of a Wildlife Service biological survey.

The larger islands in the Mercury group include Red Mercury (225 ha), Stanley (100ha), Double (32.5ha), Ohinau (=Big Ohena) (43ha), Korapuki (17.5ha) and Middle (13ha). Previous biological studies on these islands include those of Edgar (1962), Skegg (1963), Atkinson (1964), Crook (1973), Whitaker (1973, 1978) and Hicks *et al.* (1975).

The minor islands include Motukoruenga (5.9ha), Ohinauiti (=Little Ohena (5.6ha), Rabbit (3.1ha), Flat (3.3ha), Green (2.3ha), Black Rocks (2.5ha), Needle Rock (1.4ha), stack north of Stanley Island (1.25ha), Whale Rock (0.95-ha), 'Mokomoko Rock' (stack between Double and Red Mercury Islands) (0.55-ha), Old Man Rock (0.7ha), stack SE of Motukoruenga (0.5ha), stack NW of Ohinau Island (0.35ha), stack N of Korapuki Island (0.1ha), and the stack

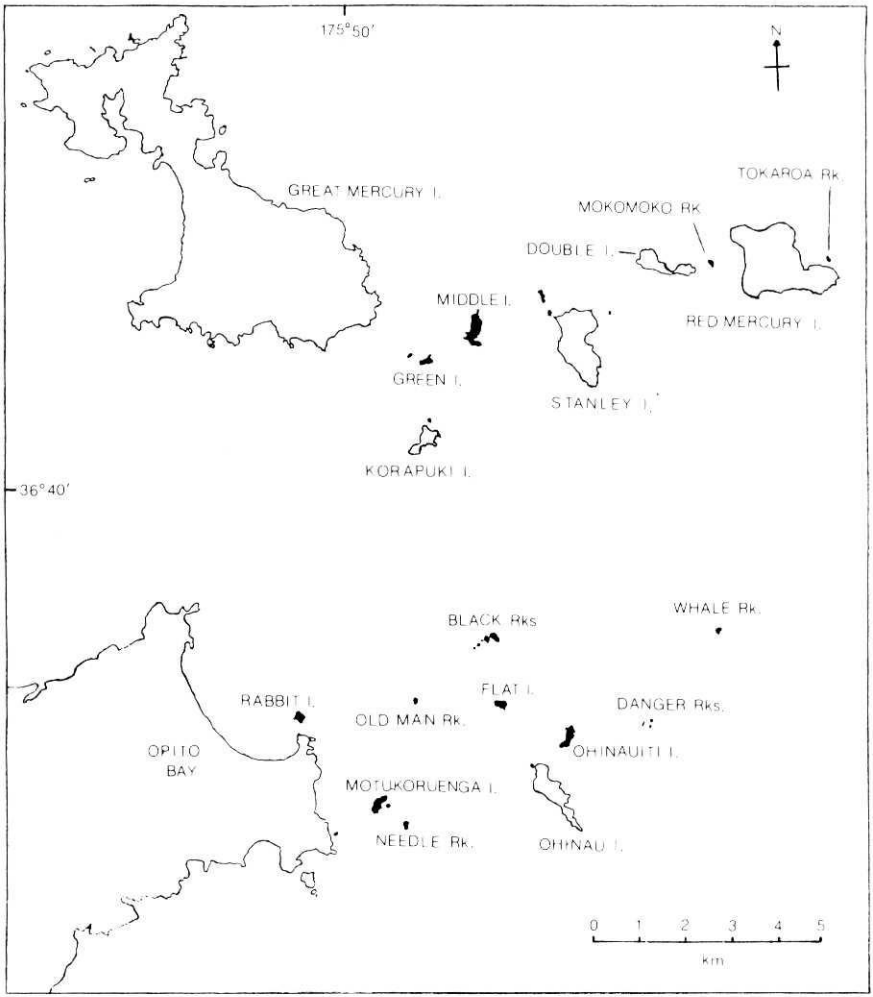

Fig.1. Location of the Mercury Islands and place names. The large islands are outlined, while the smaller islands are shaded in.

W of Green Island (0.1 ha). East of Ohinauiti Island are the wave-washed Danger Rocks. We have no information on Tokaroa Rock, which lies NW of Red Mercury Island.

The vegetation and wildlife of Green Island was described by Atkinson (1964) and Thoresen (1967) respectively. Petrels found on Ohinauiti Island were recorded by Falla (1934). Atkinson (1962) described the flora and vegetation of Old Man Rock. Towns (1972) listed the lizard fauna of 'Mokomoko Rock' and stated

that the rock was rat-free. Crook (1973) and Whitaker (1973, 1978) recorded the distribution and relative abundance of reptiles on the smaller islands in the northern subgroup. The other minor islands of the group appear to have received very little study. However, Skegg (1963) did report on a short visit to Needle Rock and described the appearance of some minor islands of the Ohinau subgroup.

This paper provides detailed information on the ecology of Black Rocks, Flat Island, and the stack 200 m west of Green Island; mostly collected in June 1987 but supplemented by observations made in 1972. In addition, we have included brief notes about eight other small islands which were visited in 1972. Each island is identified by its grid reference in the NZMS 260 map series.

The flora of the islands visited in June 1987 are given the abundance scale: abundant, common, occasional and rare. Specimens of each species were collected for checking identification but voucher herbarium specimens were not made. Nomenclature of the ferns follows Brownsey *et al.* (1985), while the angiosperms follow Allan (1961), Moore & Edgar (1970), Healey & Edgar (1980), and Healy (1984). Some of the recent name changes listed in the N.Z. Journal of Botany 'Checklists' and 'Nomina Nova' have also been used where appropriate.

Lizard nomenclature follows Hardy (1977) for skinks, and Robb & Rowlands (1977) for geckos. Prior to 1977, *Hoplodactylus pacificus* sensu McCann (1955) included the taxa now recognised as *H. pacificus* and *H. maculatus.* Observations made in 1972 have therefore been recorded as *H. 'pacificus'* as there is doubt as to the true identity of the taxon observed. Lizard voucher specimens collected in 1972 are held at the National Museum.

BLACK ROCKS (T10/U10 665963)

We landed on the larger northern island (2 ha) between 1030-1115 hrs on 10 June 1987. This is a basaltic rock measuring 250 x 100 m and rising to 20 m above sea level (Fig.2). It is capped with a small patch of coastal forest at the western end.

We located 48 species of vascular plants (Table 1). Most of the island was searched and it is unlikely that many plant species were overlooked. The forest comprises a mixture of karo *(Pittosporum crassifolium),* taupata *(Coprosma repens),* houpara *(Pseudopanax lessonii)* and *Melicytus novae-zealandiae.* Numerous large-leaved milk trees *(Streblus* sp.) and a few mahoe *(Melicytus ramiflorus)* are also present. The forest composition appears to have changed little since 1972. A deep friable soil has formed under the forest and there are patches of seabird burrows. A belt of low taupata scrub borders the forest on the southern side, while mixed ngaio *(Myoporum laetum)* and flax *(Phormium tenax)* occur on the fringe of the northern plateau (Fig. 3). Lying beyond this ecotone are a variety of adventive grasses and weeds, presumably introduced from nest material brought to the island by breeding southern black-backed

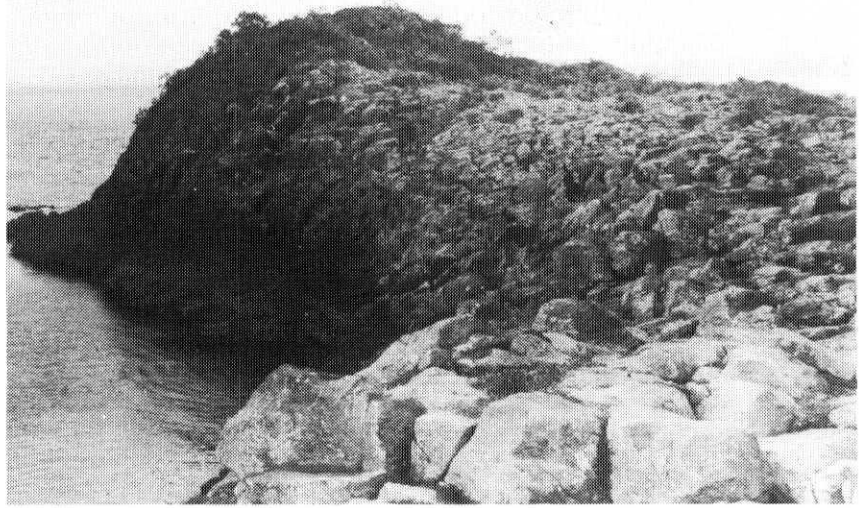

Fig.2. The north-west island of the Black Rocks group. Note the open splash-zone and small cap of forest. June 1987.

gulls *(Larus dominicanus).* Other plants may have established from seeds deposited in the nutrient enriched ground surrounding the colony.

Over half the island consists of an open area of wave-washed rocks and a splash zone above this, which is covered with a variety of coastal salt tolerant plants. Prominent amongst these are New Zealand ice plant *(Disphyma australe)* and *Samolus repens.* A few prostrate taupata are also present. A number of small brackish or stagnant pools have formed in the rock crevices and have been colonised largely by *Cotula coronopifolia.*

A smaller island lies 50m south-west of the island that we visited. It is steep sided and rises to 25 m above sea level. A landing could be made on this island from the north-east side. No obviously different plants were seen through binoculars, but the island is well vegetated and because of its height, may support species additional to those found on the larger island (Table 1). Several other rocks are present in the group; at least one of these has a small cap of vegetation.

Bird List

Burrowing petrels:

Up to 50 small burrows were counted under the forest and the ground was

quite honeycombed in small patches. Most of the burrows appeared to belong to diving petrels *(Pelecanoides urinatrix)* and small dark feathers were observed in the entrances indicating current use. Some diving petrel remains were found in the black-backed gull nests. The few larger burrows present may have belonged to fluttering shearwaters *(Puffinus gavia)* or little shearwaters *(P. assimilis)*. Diving petrel burrows were also common around the southern fringe of the island under the low scrub; several hundred burrows may be present.

Southern black-backed gull:

Many grass-lined nest scrapes were seen. The colony was deserted during the June visit.

Brief notes on other birds:

Reef heron *(Egretta sacra);* one skeleton found in a gull nest.
Australasian harrier *(Circus approximans);* one seen.
New Zealand kingfisher *(Halcyon sancta);* one seen.
Welcome swallow *(Hirundo neoxena);* one seen.
Silvereye *(Zosterops lateralis);* flock of c.10.
Blackbird *(Turdus merula);* one seen.
Goldfinch *(Carduelis carduelis);* two seen.
Greenfinch *(Chloris chloris);* heard.

Fig.3. The small coastal forest on the larger island of the Black Rocks group. June 1987.

Lizards

H. maculatus were very common. Twelve were seen in a group under one rock and similar large groups were located elsewhere. Two *Leiolopisma suteri* were found sheltering in crevices in the supralittoral zone during the recent visit. A single *L. smithi* was seen in 1972.

Mammals

No evidence was found that introduced mammals have reached this island. The abundance of lizards, karo and milktrees, and the presence of small burrowing petrels further supports this finding.

FLAT ISLAND (T10/U10 666949)

This island was visited on 10 June 1987 between 1130 and 1200 hrs. An easy landing was made on the south-west side in calm seas. Flat Island is surprisingly large (275 m by 150 m) and covers about 3.3ha. However, it is also very low lying, rising only to about 5 m above sea level in the centre. The western half of the island consists of a basaltic ridge, which has a few low stunted karo and some patches of taupata. A humus soil/leaf litter has formed at the highest point, but this patch was too small and shallow for seabirds to burrow in. Surrounding the shrubs there was a variety of native and introduced herbs, including mallow *(Malva* sp.), and grasses. Old nest sites of southern black-backed gulls were plentiful over this area.

A boulder bank has built up the eastern third of the island, and a small grove of 3-4m tall karo has established here. A shallow leaf litter was present underneath, but there was no soil. Adjacent to the grove was a small stunted patch of *M. novae-zelandiae* and also *Euphorbia glauca.* The eastern and western ridges were separated by a low, ponded channel running north/south. In this area and on the wave splash zone near the sea was the distinctive plant community of ice plant/*Sarcocornia/Samolus/Cotula.* Overall, 35 vascular plant species were found during the brief visit (Table 1).

Bird List

Burrowing petrels:

No evidence was found that any species of petrel uses the island.

Other birds:

Australasian gannet *(Sula bassana);* one dried corpse was found.
Pied shag *(Phalacrocorax varius);* one seen.
Little shag *(P. melanoleucos);* one seen.
White-faced heron *(Ardea novaehollandiae);* one seen.
Harrier; one seen.
Southern black-backed gull; 50+ seen flying over island, which is evidently used as a nesting colony.

New Zealand kingfisher; one seen.
House sparrow *(Passer domesticus);* 20 seen in a flock.

Lizards

H. maculatus, L. smithi, and *L. suteri* were all reasonably common in both 1972 and 1987.

Invertebrates

One large centipede *(Cormocephalus rubriceps)* was seen amongst the boulders.

Mammals

We found no evidence that any introduced mammals were present. The occurrence of karo, numerous lizards and the large centipede strongly suggest that rodents were absent.

UNNAMED STACK 200 m WEST OF GREEN ISLAND (T10/U10 647025)

About 20 minutes were spent ashore on this small rock (25 m by 15 m) by GAT on 8 June 1987. AHW was ashore between 1320-1355 hrs on 19 November 1972. The most accessible landing site was on the wave platform at the northern end; the rest of the stack is quite cliff bound. On the higher southern end, which rises 10 m above sea level, the ground was well vegetated. A small 2 m tall pocket of mixed scrub was present. This included karo, taupata, and *M. novae-zelandiae.* Surrounding these shrubs were low grasses and herbs typical of cliff wave-splash communities. Eighteen plant species were found on the stack; all were native except sow thistle *(Sonchus oleraceus)* (Table 1).

The ground beneath the scrub was broken rock scree and loose friable soil which extended onto a face covered with New Zealand ice plant. This soil was heavily burrowed by diving petrels. A fairly accurate count of their burrows revealed c.50 entrances. All were recently occupied judging by the fresh excreta outside the burrows. No other birds were seen.

H. 'pacificus' and *L. smithi* were common in 1972 (29 and 15 were seen respectively) and a large pale brown skink *(Cyclodina ?oliveri)* was observed. No lizards were seen in 1987 and there are no obvious reasons for their apparent absence during this latest visit. Shore earwigs *(Anisolabis littorea)* and small Tenebrionidae beetles were common under rocks.

STACK NORTH OF KORAPUKI ISLAND (T10/U10 652011)

(1235-1300 hrs on 19/11/72). There was very little vegetation present. The plant species recorded were taupata, karo, New Zealand ice plant, glasswort *(Sarcocornia quinqueflora)* and a 'grass'. A colony of white-fronted terns *(Sterna striata)* were nesting on the rock. Both *H. 'pacificus'* and *L. smithi* were present.

WHALE ROCK (T10/U10 714964)

(1605-1615 hrs on 25/11/72). This rock was sparsely vegetated. Only three species of plants were noted; glasswort, taupata and *Paspalum vaginatum*. A large red-billed gull *(Larus novaehollandiae)* colony was present. No lizards were found.

OLD MAN ROCK (T10/U10 647950)

(0830-1015 hrs on 26/11/72). Lizards recorded were; 15 *H. 'pacificus'*, two *L. smithi* and two *Cyclodina oliveri*. *C. rubriceps* was also present. The vegetation has previously been reported by Atkinson (1962).

RABBIT ISLAND (T10/U10 622947)

(1030-1115 hrs on 26/11/72). The island had apparently been burnt in the past and was scrubby. Important plants were mingimingi *(Leucopogon fasciculatus)*, karo, pohutukawa *(Metrosideros excelsa)* and flax. Grassy clearings were dominated by buffalo grass *(Stenotaphrum secundatum)*. There was no sign of lizards but rats were evident.

MOTUKORUENGA ISLAND (T10/U10 638928)

(1145-1250 hrs on 26/11/72). The island had a dense forest cover consisting mainly of pohutukawa/*Coprosma*/*Macropiper*. No sign was found of lizards in the forest but one *H. 'pacificus'* was found on the beach. The few seabird burrows present probably belonged to grey-faced petrels *(Pterodroma macroptera)*. Rats appeared to be absent from the island.

STACK NORTH-WEST END OF OHINAU ISLAND (T10/U10 672936)

(2040-2140 hrs on 26/11/72). Three *H. 'pacificus'* seen.

NEEDLE ISLAND (T10/U10 644923)

(1000-1055 hrs on 27/11/72). The vegetation was described as New Zealand ice plant and grass on some slopes; and karo/taupata/houpara/*M. novaezelandiae* on others. Eight *H. 'pacificus'* were observed. Skegg (1963) reported that diving petrels bred on this rock wherever there was sufficient soil.

STACK SOUTH-EAST OF MOTUKORUENGA ISLAND (T10/U10 640928)

(1103-1140 hrs on 27/11/72). Mahoe, karo and houpara were among the more prominent canopy species. *Carmichaelia* sp. was present in the understory, and

Microlaena and *Asplenium oblongifolium* were dominant ground covers. There were very few petrel burrows and no sign was found of any lizards.

Table 1. Vascular plant species on three islands in the Mercury Islands group.

	Flat Island	Black Rocks	Green Stack
FERNS			
Asplenium flaccidum ssp. *haurakiense*	R	C	O
A. oblongifolium	-	C	-
DICOTYLEDONS			
Anagallis arvensis *	C	O	-
Calystegia soldanella	O	-	-
Coprosma repens	O	A	A
*Coronopus didymus**	R	-	-
Cotula australis	O	-	-
C. coronopifolia	A	A	-
Crassula sieberiana	O	R	-
Dichondra repens	C	C	A
Disphyma australe	A	A	A
Einadia trigonos	R	O	C
Euphorbia glauca	O	-	-
*Leontodon taraxacoides**	-	R	-
Linum monogynum	-	R	-
Lobelia anceps	-	-	O
*Lotus suaveolens**	-	O	-
*Lycium ferocissimum**	-	R	-
*Lycopersicon esculentum**	O	R	-
Macropiper excelsum	-	R	-
Malva sp. (mallow)*	C	-	-
Melicytus novae-zelandiae ssp. *novae-zelandiae*	R	C	C
M. ramiflorus ssp. *ramiflorus*	-	O	-
Muehlenbeckia complexa	-	O	O
Myoporum laetum var. *excelsum*	-	A	-
*Phytolacca octandra**	-	O	-
Pimelea prostrata	-	R	-
Pittosporum crassifolium	A	A	A
*Plantago major**	R	-	-
Pseudopanax lessonii	-	A	-
Rumex sp. *(conglomeratus/crispus)**	C	-	-
Samolus repens	A	A	-
Sarcocornia quinqueflora ssp. *quinqueflora*	A	C	A
Senecio lautus ssp. *lautus*	C	C	A
Sicyos angulata	-	O	-
Solanum americanum	O	-	?R
*S. nigrum**	O	O	-
*Sonchus oleraceus**	C	O	R
Spergularia media	C	C	O
*Stellaria media**	O	-	-

Streblus sp. *(Paratrophis banksii)*	-	O	-
Tetragonia trigyna	-	O	-
MONOCOTYLEDONS			
Arthropodium cirratum	-	R	-
Astelia banksii	-	R	-
*Bromus willdenowii**	C	-	-
Carex flagellifera	-	O	?R
*Cortaderia selloana**	R	R	-
Cyperus ustulatus	O	O	-
*Dactylis glomerata**	-	O	-
*Eleusine indica**	A	-	-
Leptocarpus similis	-	R	-
Oplismenus imbecillis	-	C	-
*Paspalum dilatatum**	-	O	-
*P. vaginatum**	C	A	-
Phormium tenax	-	C	-
Poa anceps ssp. *anceps*	R	?R	O
P. pusilla	-	?R	-
Rytidosperma sp.	-	O	-
Scirpus cernuus	O	C	C
S. nodosus	C	C	O
*Sporobolus africanus**	O	-	-

Abundance Scale A = abundant (locally dominant)
C = common
O = occasional (scattered)
R = rare (one or several only)
? = status uncertain
- = absent

* denotes adventive species

DISCUSSION

In contrast to the larger islands of the Mercury group, the minor islands (all under 13ha) have largely escaped being modified by man's activities. Only Rabbit Island, lying close to Opito Bay, shows evidence of direct disturbance; in this case by burning, and the presence of rodents. The flora of the small islands visited in June 1987 (Flat Island, Black Rocks and the stack 200 m west of Green Island) shows strong similarities to the other unmodified small islands previously studied in northern New Zealand (Table 2). These 12 islands range in size from 0.1ha to 13ha.

Of the small islands listed (Table 2), Otawhanga Island (2 ha) has the greatest diversity of native plants (51 spp.). This is perhaps explained by its close proximity to the mainland and the larger Rimariki Island. Otawhanga is also fairly steep-sided and has a range of habitats. Motuwhararíki (0.6 ha) and Little Otawhanga (0.2 ha) are similar in shape and close to Otawhanga, but their smaller size probably explains their lower plant diversity (41 and 22 spp. respectively) (Cameron 1986). The diversity of plant species on the small islands of

the Mercury group generally decreases with island size. The two exceptions are Flat Island and Old Man Rock. Flat Island (3.3ha) is low-lying and has very few habitats compared with all the other islands, and thus a smaller flora (19 spp.) Old Man Rock (0.7 ha) is steep-sided and high, and this diverse habitat supports 36 native plant species. Old Man Rock and Sail Rock (3.4ha) are similar in height and habitat diversity, and they have a similar number of plant species (36, 39 respectively) (Atkinson 1962, 1972). The close proximity of Old Man Rock to the mainland apparently offsets the difference in island size when compared with the more isolated Sail Rock. Isolation and habitat diversity appear to be more important than island size in determining plant species distribution in the Aldermen group (Court *et al.* 1973).

Thus plant species diversity on each island was positively correlated with island area and height, and negatively correlated with distance from the mainland or other islands, as predicted by island biogeography theory (Macarthur and Wilson 1967). Generally, the greatest diversity of plants is expected from large and high islands nearest the mainland.

Although a total of 95 native vascular plant species was found on the islands listed in Table 2, the island with the greatest diversity still had only 51 species. Overall, 37 plant species occurred on only one or two of the 12 islands. Perhaps the presence of some plants can be explained by chance dispersal but it is more likely that for many species, the suitability and diversity of site factors are important.

Only five plant species were common to all of the 12 undisturbed islands. They were karo, taupata, New Zealand ice plant, *Asplenium flaccidum* ssp. *haurakiense* and glasswort. Another five species were found on most of the islands; these were *Dichondra repens, M. novae-zelandiae, Muehlenbeckia complexa, P. anceps* and shore groundsel *(Senecio lautus).* These 10 widespread species, except karo, are also found on larger and modified islands. However they are less abundant where browsing mammals are present.

Karo is uncommon on modified islands, especially those with kiore. Atkinson (1972, 1986) has suggested that kiore are capable of preventing the regeneration of both karo and large-leaved milk tree as they readily feed on the seeds of these species. Atkinson (1986) compared the distribution and abundance of milk tree on islands with and without kiore and found only old mature trees were present (if at all) on kiore islands, while trees of all ages occurred on islands without kiore. In our study milk trees were absent from the low-lying Flat Island and the two smallest islands ($\leq$ 0.2 ha), presumably because there was no suitable habitat, and they are not known from Hernia Island (Court *et al.* 1973) or the apparently suitable Green Island. Milktrees were present on the seven remaining islands.

Some other plant species have a patchy distribution on unmodified islands. For example, pohutukawa is present on most, but not all of these islands. In contrast with larger islands where it is often dominant, on unmodified islands this species is usually found only on exposed cliffs. Surprisingly, houpara, *S.*

repens, and *Scirpus nodosus* were absent from some of these islands. These species seem to be almost ubiquitous on most coastal cliff sites.

Flax was sparse on most of these small islands and even absent from some but it is usually abundant on islands that have been burnt. The widespread sedge *Cyperus ustulatus* was found on all but the three smallest stacks.

The number of adventive plant species found on these islands (Table 2) varied considerably. The presence of open or disturbed ground available for colonising plants appears to be less important than the dispersal vectors. For example, amongst the islands listed in Table 2, the two in the Alderman group were most distant from the mainland and had the least adventive species (1 spp. on each). Amongst islands which are a similar distance from the mainland and with similar habitats, the presence of dispersal vectors such as roosting starlings *(Sturnus vulgaris)* or nesting gulls becomes paramount. Flat Island and Black Rocks have many introduced plants as the open habitats associated with the gull colonies are presumably favourable sites for these plants to establish. Middle and Green Islands had more introduced plants (6 and 8 spp. respectively) than the stack west of Green Island (1 spp.), probably because starlings roost there (Skegg 1963) but not on the stack. All three islands had open habitat on the cliffs and ledges, suitable for colonising plants, but seeds deposited by starlings would greatly assist this process.

Table 2. Comparison of the native vascular flora on small undisturbed islands in northern New Zealand.

	A	B	C	D	E	F	G	H	I	J	K	L
Apium prostratum ssp. *prostratum*	-	+	-	-	-	+	-	+	-	+	-	-
Arthropodium cirratum	+	+	-	-	-	+	+	-	-	+	-	-
Asplenium flaccidum ssp. *haurakiense*	+	+	+	+	+	+	+	+	+	+	+	+
A. oblongifolium	+	+	-	-	+	+	+	-	+	+	-	-
Astelia banksii	-	+	-	-	+	+	+	-	+	+	-	-
Brachyglottis repanda	+	-	-	-	-	-	-	-	-	-	-	-
Calystegia soldanella	-	-	-	+	-	-	-	-	-	-	-	-
C. turguriorum	-	+	-	-	-	-	-	-	-	-	-	-
Carex breviculmis	-	-	-	-	-	+	-	-	-	-	-	-
C. dissita	-	-	-	-	-	-	-	-	-	+	-	-
C. flagellifera	+	-	-	-	?	-	+	-	-	+	-	?
C. testacea	-	-	-	-	+	-	-	-	-	-	-	-
Carmichaelia aligera (incl. *C. cunninghamii)*	+	-	-	-	-	-	-	-	-	-	-	-
C. williamsii	-	-	-	-	+	-	-	+	-	+	-	-
Cheilanthes distans	-	-	-	-	-	+	-	-	-	-	-	-
C. sieberi	-	-	-	-	+	-	-	-	-	-	-	-
Chionochloa bromoides	-	-	-	-	-	+	-	-	-	+	+	-
Clematis paniculata	+	+	-	-	-	-	-	-	-	-	-	-
Collospermum hastatum	-	-	-	-	-	-	-	-	+	-	-	-
Coprosma macrocarpa/robusta	+	+	-	-	-	+	-	-	-	+	-	-
C. repens	+	+	+	+	+	+	+	+	+	+	+	+
Cordyline australis	-	-	-	-	+	-	-	-	-	-	-	-

	A	B	C	D	E	F	G	H	I	J	K	L
Corynocarpus laevigatus	+	-	-	-	+	+	-	-	-	+	-	-
Crassula sieberiana	+	+	-	+	-	-	+	-	-	-	-	-
Cyperus ustulatus	+	+	+	+	+	+	+	+	+	-	-	-
Deyeuxia billardieri	+	+	-	-	-	-	-	+	+	+	-	-
Dianella nigra	-	-	-	-	-	+	-	-	-	-	-	-
Dichelachne crinita	-	-	-	-	+	+	-	-	-	+	+	-
Dichondra repens	+	+	+	+	+	+	+	-	+	+	+	+
Disphyma australe	+	+	+	+	+	+	+	+	+	+	+	+
Doodia media ssp. ***australis****	+	-	-	-	-	-	-	-	-	-	-	-
Dysoxylum spectabile	+	-	-	-	-	-	-	-	-	-	-	-
Einadia trigonos	+	+	-	+	-	-	+	-	-	-	-	+
E. triandra	-	-	-	-	+	+	-	+	+	-	+	-
Elymus multiflorus	-	-	-	-	+	+	-	-	-	+	-	-
Euphorbia glauca	-	-	-	+	-	-	-	-	-	-	-	-
Gahnia lacera	-	-	-	-	-	-	-	-	-	+	-	-
Geniostoma ruprestre var. ***ligustrifolium***	-	-	-	-	-	-	-	-	-	+	-	-
Gnaphalium audax ssp. *audax*	-	-	-	-	-	+	-	-	-	+	-	-
G. gymnocephalum	-	-	-	-	-	+	-	-	-	-	-	-
Lachnogrostis filiformis	-	-	-	-	-	-	-	-	-	+	+	-
Lepidium oleraceum	+	+	-	-	-	-	-	+	+	-	-	-
Leptocarpus similis	-	-	-	-	-	-	+	-	-	-	-	-
Leucopogon fasciculatus	-	-	-	-	-	+	-	-	-	+	+	-
Linum monogynum	-	-	+	-	-	-	+	-	+	-	-	-
Lobelia anceps	+	-	-	-	-	-	-	+	-	-	-	+
Macropiper excelsum var. *excelsum*	+	+	-	-	-	+	+	-	-	+	-	-
Melicope ternata	+	+	-	-	+	+	-	-	+	-	-	-
Melicytus novae-zelandiae ssp. *novae-zelandiae*	+	+	+	+	+	+	+	+	+	-	-	+
M. ramiflorus ssp. *ramiflorus*	+	+	-	-	+	+	+	-	-	+	-	-
Metrosideros excelsa	+	+	+	-	-	+	-	+	+	+	+	-
Microlaena polynoda	-	-	-	-	+	-	-	-	+	-	-	-
Muehlenbeckia australis	-	-	-	-	-	+	-	-	-	-	-	-
M. complexa	+	+	+	-	+	+	+	-	+	+	+	+
Myoporum laetum	+	+	-	-	-	-	+	+	-	-	-	-
Myrsine australis	+	-	-	-	-	+	-	-	-	-	-	-
Oplismenus imbecillis	+	-	-	-	-	-	+	-	+	-	-	-
Oxalis corniculata	+	-	?	-	-	-	-	-	-	-	-	-
O. rubens (O. stricta sensu Allan 1961)	-	-	-	-	-	+	-	-	-	+	-	-
Parietaria debilis	+	+	-	-	-	+	-	-	+	-	-	-
Parsonsia heterophylla	+	-	-	-	-	-	-	-	-	-	-	-
Peperomia urvilleana	-	+	-	-	+	+	-	-	+	-	+	-
Phormium tenax	+	+	-	-	-	+	+	+	+	+	+	-
Phymatosorus diversifolius	-	-	-	-	+	+	-	-	-	+	-	-
Pimelea prostrata	-	-	+	-	-	+	+	-	-	+	+	-
Pittosporum crassifolium	+	+	+	+	+	+	+	+	+	+	+	+
P. umbellatum	-	-	-	-	-	-	-	-	-	+	-	-
Planchonella costata	+	+	-	-	-	+	-	-	+	+	-	-
Poa anceps ssp. *anceps*	+	-	+	+	-	+	?	+	+	+	+	+
P. pusilla	-	-	-	-	-	-	?	-	-	-	-	-
Pratia physaloides	-	-	-	-	+	-	-	-	-	-	-	-
Pseudognaphalium luteoalbum	-	+	-	-	-	+	-	-	-	-	-	-
Pseudopanax lessonii	+	+	+	-	-	+	+	+	+	-	+	-

	A	B	C	D	E	F	G	H	I	J	K	L
Pteridium esculentum	-	-	-	-	-	+	-	-	-	+	-	-
Pyrrosia eleagnifolia	-	+	-	-	+	+	-	-	+	-	-	-
Rytidosperma sp.	-	-	+	-	-	-	+	-	-	-	-	-
R. biannulare	-	-	-	-	-	+	-	-	-	-	+	-
R. unarede	-	-	-	-	+	+	-	-	-	+	-	-
Samolus repens	-	+	-	+	-	+	+	-	-	+	+	-
Sarcocornia quinqueflora ssp. *quinqueflora*	+	+	+	+	+	+	+	+	+	+	+	+
Scandia rosaefolia	-	-	-	-	+	-	-	-	-	-	-	-
Scirpus cernuus	+	+	-	+	-	-	+	-	+	-	-	+
S. nodosus	-	-	+	+	-	+	+	-	+	+	+	+
Senecio bipinnatisectus	-	-	+	-	-	-	-	+	-	-	-	-
S. lautus ssp. *lautus*	+	+	-	+	+	+	+	-	+	+	+	+
Sicyos angulata	+	+	-	-	+	-	+	-	+	-	-	-
Solanum americanum	+	+	-	+	+	+	-	+	-	-	-	?
S. aviculare	+	+	-	-	+	-	-	+	-	-	-	-
Sonchus kirkii	-	-	-	-	-	-	-	-	+	-	-	-
Spergularia media	-	+	-	+	+	-	+	-	-	-	-	+
Stellaria parviflora	+	+	+	-	+	-	-	+	-	-	-	-
Streblus sp. *(Paratrophis banksii)*	+	-	-	-	+	+	+	+	+	+	-	-
Tetragonia trigyna	-	-	+	-	+	-	+	-	+	-	-	-
Thelymitra longifolia	-	-	-	-	+	+	-	-	+	-	-	-
Wahlenbergia gracilis agg.	+	+	-	-	+	-	-	-	+	-	-	-
Total native species	46	41	21	19	39	51	35	24	36	41	22	17
Introduced species	6	8	1	16	6	21	13	1	4	17	18	1

\+ = present
? = status uncertain
\- = absent

Island A = Middle (Mercury group) .13 ha (Atkinson 1964)
B = Green (Mercury group) 2.3 ha (Atkinson 1964)
C = Hernia (Aldermen group) 3.4 ha (Court *et al.* 1973)
D = Flat (Mercury group) 3.3ha (this study)
E = Sail Rock (Hen and Chickens group) 3.4ha (Atkinson 1972)
F = Otawhanga (Rimariki group) 2.0 ha (Cameron 1986)
G = Black Rocks (Mercury group) 2.0 ha (this study)
H = Half (Aldermen group) 1.6 ha (Court *et al.* 1973)
I = Old Man Rock (Mercury group) 0.7 ha (Atkinson 1962)
J = Motuwhararikl (Rimariki group) 0.6 ha (Cameron 1986)
K = Little Otawhanga (Rimariki group) 0.2 ha (Cameron 1986)
L = Stack W of Green Is. (Mercury group) 0.1 ha (this study)

* E.K. Cameron pers. comm. (not *Blechnum* sp. as reported in Atkinson 1964)

These small undisturbed islands are often refuges for a variety of animal species which are scarce or absent on larger or modified islands, particularly those colonised by rodents. Small species of petrel are particularly common on rat-free islands. Many of the islands in Table 2 have large breeding

populations of diving petrels. This petrel is very rare or absent on islands harbouring rats. Sometimes, other species of petrel breed on the small unmodified islands. The tiny white-faced storm petrel *(Pelagodroma marina)* only occurs on relatively undisturbed, rat-free islands but in the Mercury group is apparently restricted to Ohinauiti Island (Skegg 1963), indicating factors other than modification can affect their breeding distributions. Similarly, fairy prions *(Pachyptila turtur)* are only known from the predator-free Poor Knights Islands in northern New Zealand (Falla 1934), yet south of Cook Strait, prions breed abundantly on most small rat-free islands. The small little shearwater and Pycroft's petrel *(P. pycrofti)* are mostly confined to breeding sites on large northern offshore islands. These petrels may have specific nest site requirements that only occur on the larger islands. Most of these island groups have been modified by man and usually kiore are present.

Whether kiore have affected populations of petrels will not be known until kiore are eradicated from islands where petrels breed. The larger burrowing petrels are usually common on large kiore-inhabited islands. However these petrels are only abundant on small islands where there is sufficient soil suitable for burrowing. The situation is very different on islands with *R. norvegicus* and *R. rattus.* These rats have caused the decline or local extinction of numerous populations of petrels (Atkinson 1985). Thus commensal rats, and also feral cats *(Felis catus),* are the greatest threats to seabird populations on islands.

On unmodified islands the diversity of lizards is strongly correlated with habitat diversity (Whitaker 1978, Towns & Robb 1986) which in turn is often a function of island size. When rats (usually kiore) are present the diversity and density of lizards drops dramatically such that small islands, even if only a few hectares in size, often support lizard populations with much greater abundance and diversity than on rat-inhabited islands many times their size. This has already been shown for some of the Mercury group (Gibb & Flux 1973, Whitaker 1978) and is supported by the observations reported here.

Ramsay (1978) examined the effects of rodents on terrestrial invertebrates and concluded that large flightless species are the most vulnerable group. Watt (1986) compared the beetle faunas on northern offshore islands and found striking differences between islands with and without rodents. Most of the endemic species are restricted to rat-free islands but some may have been more widespread in the past. In particular large flightless weevils in northern New Zealand are found mainly on rat-free islands. Watt (1986) has found that an abundant population of darkling beetles *(Mimopeus elongatus)* (Tenebrionidae) on an island is a sure sign that rats are absent. Faunal diversity is low on small islands compared with equivalent areas of the mainland. The main limitation appears to be the low diversity of niches available.

Atkinson (1986) examined the influence of kiore on invertebrate populations. One finding was that *C. rubriceps* occurred mainly on unmodified or rat-free islands. Thus small rat-free islands are worth checking for invertebrate fauna that may be restricted to these islands by modification of habitats elsewhere.

Future surveys of these small islands will be useful to investigate the stability of comparatively unmodified ecosystems, and to check for the presence of rodents. Inventories of plant species are still needed from a few islands in the Mercury group. In addition, future expeditions should obtain a quantitative assessment of the flora and fauna on these small islands, e.g. permanent plots and photopoints. These islands can then provide a baseline to compare with future surveys or with nearby modified coastal habitats.

Much of what we know or presume about biotic relationships on islands is based on the presence or absence of species from particular groups (Crook 1973, Whitaker 1978). Therefore it is important that we develop a more experimental approach to research on islands. There are two ways this goal can be achieved. Firstly, the current attempts to eradicate rats from islands (Moors 1985) should provide valuable experimental situations for those studying changes in the flora and fauna of islands inhabited by rats. Close monitoring of sample plots should always be part of the management procedure on islands chosen for eradication of rodents (or other mammals). Secondly, very little attention has been paid to the relative importance of habitat disturbance as opposed to mammal predation on island biotas. Small islands free of rats and carnivores, but burnt off and/or grazed in the past, should be studied to see which elements of their flora and fauna have been most effected by this type of habitat disturbance.

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