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STOATS (*MUSTELA ERMINEA)* ON ADELE AND FISHERMAN ISLANDS, ABEL TASMAN NATIONAL PARK, AND OTHER OFFSHORE ISLANDS IN NEW ZEALAND

Summary: Adele (87 ha) and Fisherman (3.6 ha) Islands lie 800 m and 1100 m, respectively, offshore in Tasman Bay, Nelson. Both are covered predominantly in native forest and scrub. There are mice (*Mus musculus)* on Adele Island but no rodents on Fisherman Island. Both islands are within swimming range of stoats (*Mustela erminea)* which have colonised Adele Island and occasionally visit Fisherman Island, 700 m distant.

Fourteen stoats were trapped on Adele Island between August 1980 and February 1981. Continued trapping (12637 additional trap-nights) up to August 1983 caught only four more, but stoat tracks were still occasionally being found on the islands' sandy beaches. At their original density of about one per 9 ha stoats were readily reduced to low numbers by trapping, but on Adele Island colonisation apparently continued at the rate of one *or* two stoats per year.

Twenty-six New Zealand offshore islands are now known to have been colonised or visited by stoats, and many others closer than 1200 m from a stoat-infested shore are considered likely to have stoats or to be within reach of them.

Keywords: *Mustela erminea*; Mustelidae; *Mus musculus*; Muridae; Adele Island; Fisherman Island; Abel Tasman National Park; New Zealand; trapping; population density; food habits; dispersal; colonisation; offshore islands.

Introduction

New Zealand has over 630 offshore islands, of which only a few have remained undisturbed by human developments and animal introductions over the last 200 years (Atkinson and Bell, 1973; Merton, 1977). These few unmodified islands are extremely valuable for conservation, both as samples of undisturbed ecosystems (Taylor, 1968) and as actual *or* potential refuges for native species under threat *of* extinction elsewhere (Mills and Williams, 1979).

Stoats *(Mustela erminea)* were introduced to New Zealand in the 1880s and are generally acknowledged to have been one of the main causes of extinctions and the marked decline in numbers of native birds over the last 100 years King, 1981). Stoats are good swimmers and have spread unaided to many islands off the New Zealand coast (Taylor, in press). The recent dispersal of stoats to Maud Island Nature Reserve (Bell, 1983), 900 m offshore in Marlborough Sounds Maritime Park, illustrates the need to identify islands vulnerable to invasion by stoats and to devise methods of removing stoats and preventing recolonisation.

In this paper we report on a trapping study o*f* stoats on Adele and Fisherman Islands in Abel Tasman National Park (Fig. 1) and discuss the colonisation by stoats of other offshore islands in New Zealand. The objectives of our trapping study were to determine the density and sex and age structure of the islands' stoat populations, whether stoats can be exterminated from an island by trapping, the rate of re-colonisation

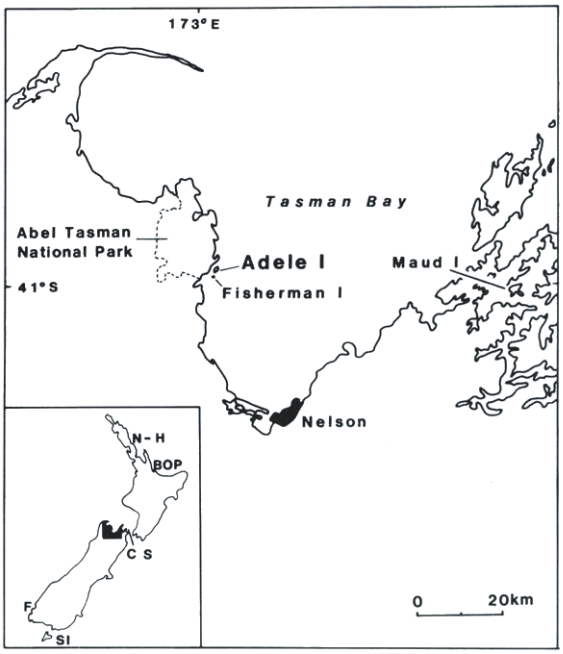

Figure 1: *Localities and geographical regions mentioned* in the *text*. N-H, *Northland/Hauraki; BOP, Bay of Plenty;* CS, *Cook Strait; F, Fiordland; SI, Stewart Island.*

from the mainland, and the stoats' foods on the islands. The results of a concurrent project aimed at measuring the effect of stoat control on the islands' bird populations will be published separately.

Study Areas

Adele Island (40 º 59'S, 173º 04'E) is 87 ha in area and lies 800 m off the coast to the north of Sandy Bay, Abel Tasman National Park. Fisherman Island (3.6 ha) is 700 m from Adele Island and 1100 m from the nearest mainland. Both islands are covered mainly with native forest and scrub but there are patches of *Hakea salicifolia* and scattered young pines *(Pinus radiata)* on Adele Island and clumps of gorse *(Ulex europaeus)* on both.

Adele Island rises steeply to a central ridge, the highest point being 120 m a.s.l. There are three small, sandy beaches on the otherwise rocky shoreline, and a sandspit extends 100 m west from the island towards the mainland coast. Even-aged areas of scrub and low forest, and expanses of unvegetated ground, indicate modification by burning within the last 100 years. Kanuka *(Leptospermum ericoides)* and black beech *(Nothofagus solandri)* predominate on the steeper and drier north- and west-facing slopes and broad-leaved tree species such as mahoe *(Melicytus ramiflorus)* and five-finger *(Pseudopanax arboreus)* and an understorey of ferns provide the dominant vegetation on the south and east slopes.

The thin granite soil on the higher parts of the island supports only a sparse low cover of kanuka, manuka *(Leptospermum scoparium),* two species of *Cyathodes,* bracken *(Pteridium aquilinum)* and scattered black beech.

The vegetation of Fisherman Island does not appear to have been modified by man since Maori occupation. Broad-leaved tree species predominate on the southern part of the island, and the northern faces support a more scrubby vegetation, with black beech also present. There are two small sandy beaches on the south coast.

The common native bush birds on both islands are bellbird *(Anthornis melanura),* grey warbler *(Gerygone igata),* fantail *(Rhipidura fuliginosa),* and silvereye *(Zosterops lateralis).* There are a few yellow-breasted tits *(Petroica macrocephala)* on Adele Island and New Zealand pigeons *(Hemiphaga novaeseelandiae)* frequent both islands. Common introduced species are blackbird *(Turdus merula),* song thrush *(T. philomelos),* chaffinch *(Fringilla coelebs),* redpoll *(Carduelis flammea),* greenfinch *(Carduelis chloris)* and hedge sparrow *(Prunella modularis).* Common sea birds are black-backed gull *(Larus dominicanus),* red-billed gull (L. *novaehollandiae),* blue penguin *(Eudyptula minor),* variable oystercatcher *(Haematopus unicolor)* and spotted shags *(Stictocarbo punctatus).* Shags roost in large numbers on Adele Island. There are no burrowing petrels.

Mice *(Mus museulus)* occur on Adele Island but there are no rodents on Fisherman Island. Stoats were first recorded from Adele Island in 1977 (J. Kilby, pers. comm.) and from Fisherman Island during the present study, though stoats may have been present on these islands for many years.

Methods

Stoats

Stoats were caught and killed in Fenn traps (King, 1973) set in pairs under a trapping tunnel which was designed to exclude birds. A wide range of baits was used, including 'Felix' cat food, sausages, eggs, fish and portions of hare *(Lepus capensis)* carcasses. Traps were set at up to 15 sites on Adele Island and up to five sites on Fisherman Island (Fig. 2). They were checked and rebaited at least once every month from August 1980 to August 1983 on Adele Island, and in November and December 1981 and from February to April 1982 on Fisherman Island. Rates of capture are given as captures per 100 trap nights (C/100 TN) after correcting for unavailable traps by the method of Nelson and Clark (1973).

Apart from trapping for stoats, we regularly searched for stoat tracks on the sand beaches of both islands.

Autopsy data from animals collected included sex, weight, age class, and stomach and gut contents. Age determination followed King and Moody (1982a) and was based on skull characteristics and baculum weight in males. Stomach and gut contents were washed in a fine (No. 18) sieve and then sorted microscopically. Prey remains identified included feathers and bones of birds; hairs, bones and teeth of mice, rats and stoats; bones and scales of fish; and exoskeletons of invertebrates. Because some stoats were very badly decomposed when recovered

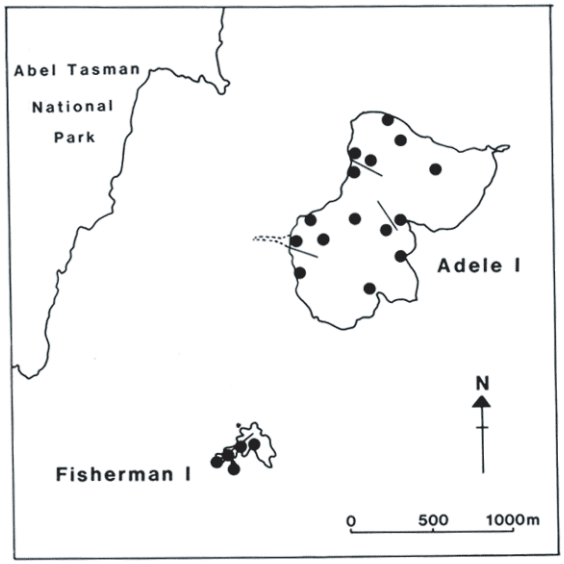

Figure 2: *Adele and Fisherman Islands showing the position of stoat traps* (•) *and rodent trap lines* (—).

from the traps the sex and age of two and the stomach and gut contents of four were not determined.

Rodents
Traplines of paired rat and mouse snap-traps under sheet aluminium covers were set on Adele Island in February 1981 and on Fisherman Island in November 1981 to check for the presence of rats and mice (Fig. 2). A mixture of peanut butter and rolled oats was used as bait. The rodent lines on Adele Island, totalling 26 sets, were operated over four nights, four times yearly, in February, May, August and November, from 1981 to February 1983 to monitor mouse population levels.

Results

Stoat trapping
Eighteen stoats (9 males, 7 females, 2 unsexed) were trapped on Adele Island from August 1980 to August 1983. Eight of these were caught in 50 Fenn trap-nights in the first month of trapping. The next 408 trap-nights (up to 28 February 1981) caught six more, and thereafter only four stoats were trapped in 12637 further trap-nights (see Table 1 and Fig. 3). Of the 14 stoats trapped

Table 1: *Results of Fenn trapping on Adele Island.* (W = *June, July, August; Sp = September, October, November;* S *= December, January, February; A = March, April, May)*

Season	Trap nights	Stoats caught			
		Males	Females	Not sexed	Total
1980 W	50	5	3		8
Sp	112	2			2
— S	296	2	1	1	4
A	1,181		1		1
1981 W	1,248		1		1
Sp	1,317				
— S	1,274				
A	1,380				
1982 W	1,362		1		1
Sp	1,315				
— S	1,256			1	1
A	1,314				
1983 W	990				
TOTALS	13,095	9	7	2	18

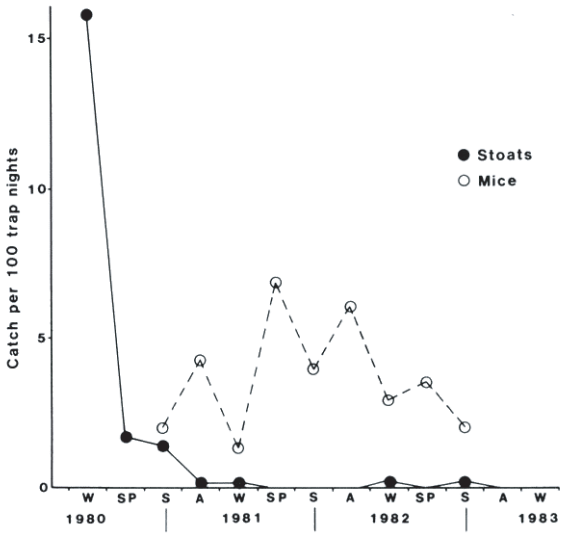

Figure 3: *Stoat and mouse population indices on Adele Island. (W, Sp,* S, *A as for Table 1). Index trapping of mice was from February 1981 to February 1983 only; that for stoats from August 1980 to August 1983.*

between August 1980 and February 1981, 11 (8 males, 3 females) were adults, two were young males, and one was not aged or sexed. The four stoats caught since May 1981 comprised three

nominal adult females and one other which was not aged or sexed.

No stoats were trapped in a total of 207 Fenn trap-nights on Fisherman Island.

At the start of the study stoat tracks were regularly seen on Adele Island's beaches, but after August 1981 they were found only in July, August and September 1982 and in May, June and August 1983. On Fisherman Island stoat tracks were found only in November 1981 and in February 1982.

Stoat diet

The contents of the stomachs and intestines of 14 trapped stoats were examined (Table 2). Invertebrate fragments were from Coleoptera and Hymenoptera, rat material was *Rattus rattus,* fish bones and scales were mostly from small fish (<100 mm long), and bird remains identified were from land birds, including silvereyes and blackbirds. Five stomachs were completely empty and four contained only a trace of food. Three of the stoats with empty stomachs had identifiable traces of food in the intestines. The stomach and/or intestines of eight animals contained fragments of vegetation (mainly leaves) and three had sand, grit and small pieces of gravel.

Table 2: *Occurrence of prey remains in stomachs and intestines of 14 stoats from Adele Island.*

	Prey remains						
	Invertebrate	Fish	Bird	Mouse	Rat	Stoat	Unident. flesh
M Aug 1980	x	x	x			x	
F Aug 1980							x
F Aug 1980		x					
M Aug 1980				x			
M Aug 1980							x
F Aug 1980	x						x
M Aug 1980							
M Aug 1980					x		
M Oct 1980		x					
M Oct 1980	x		x				
M Feb 1981							
F May 1981	x	x					
F Aug 1981			x				
F Jly 1982				x			
Total occurrences	4	4	3	2	1	1	3
% occurrence	28	28	21	14	7	7	21

Rodents

Mice were the only rodents found on Adele Island and there was no sign of either mice or rats on Fisherman Island. Mouse population indices from snap-trapping on Adele Island were low (1-7/100 TN) and trends throughout 1981-82 showed no correlation with lowered stoat numbers (Fig. 3).

Discussion

Stoats on Adele and Fisherman Islands

The 10 adult stoats trapped on Adele Island in the three months from August to October 1980 indicate a density of about one stoat per 9 ha. This density appears high compared with most previous quantitative estimates of *Mustela erminea* densities in the northern hemisphere (Table 3), although these other populations are from higher latitudes. We have not found any density estimates for other New Zealand stoat populations, but King and MacMillan (1982) gave density indices of 8.2 and 10.7 new captures per 100 TN during a peak summer for stoats in two Fiordland areas in 1979-80. The capture rate on Adele Island during August 1980 was 16/100 TN (Fig. 3).

The comparatively high density found on Adele Island may perhaps be explained by the wide range of food resources (e.g., sea and bush birds, invertebrates, mice, shore-line flotsam) and the lack of competition from other mammal predators. Our very limited data on the diet of the Adele Island stoats indicate that they were feeding to a large extent on invertebrates, fish and birds, and less frequently on mice, perhaps because the mouse population was low (about 2/100 TN) when most stoats were trapped. The presence of leaves, twigs, grit and sand in the stomachs and intestines suggests feeding and

Table 3: *Reported population densities of* Mustela erminea.

Reference	Locality	Density (ha/ stoat)
Present study	Adele I, N.Z.	9
Erlinge (1983)	Sweden	10
Simms (1979)	Eastern Canada	16
Soper (1919)	Western Canada	25
Vaisfeld (1972)	Northern Russia	26
Erlinge (1977)	Sweden	28
Debrot (1981)	Switzerland	37

scavenging in the forest litter and along the shore. The significance of the rat remains found in one stoat is uncertain. They could have come from a carcass carried by a gull or washed up on the shore, or alternatively the stoat may have very recently arrived from the mainland.

The gap of 11 months from August 1981 to July 1982 in which no stoats were caught on Adele Island in over 4000 trap-nights (and no stoat tracks were found), suggests that at that stage the island's resident stoat population had been eradicated and the two animals caught later were new colonists from the mainland (Fig. 4). In the case of Adele Island, 800 m offshore, colonisation is apparently occurring at the rate of 1-2 stoats per year. On Fisherman Island, the complete lack of trapping success and the absence of tracks on the beaches, except during two months of the three-year study, indicates that stoats were making only occasional short visits.

Our results indicate that Fenn trapping will effectively lower high stoat populations on islands, but at low density new colonists or occasional visitors seem difficult to trap. This is a serious problem since one female immigrant can quickly lead to the re-population of an island. Virtually all adult females are impregnated shortly after giving birth in October, and young females are already pregnant, with 9-10 blastocysts in delay, on leaving their family group in summer

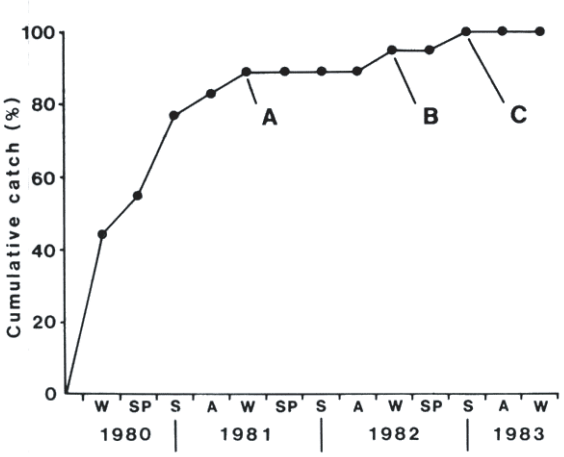

Figure 4: *Cumulative catch of stoats on Adele Island plotted against trapping periods, showing the suggested stages at which the resident population was trapped out (A) and new colonists caught (B and C). (W, Sp,* S, *A as for Table* 1).

(King, 1981; King and Moody, 1982b). More studies of stoat behaviour and the development of new control techniques are very necessary if certain islands important for conservation (e.g. Maud Island) are to be kept clear of stoats.

Stoats on New Zealand offshore islands

This study and records from other New Zealand islands suggests that stoats may colonise accessible islands of at least 90 ha in size and temporarily visit much smaller islets or those with limited food supplies.

Twenty-six New Zealand offshore islands (Table 4) are now reported to have been colonised or visited by stoats. The "water crossing" given for each island refers to the widest single stretch of water a colonising or visiting stoat would need to swim from its likely population of origin. Table 5 compares the relative accessibility of islands with stoats with that of 39 others understood to be free of stoats. It is not known whether stoats are present or absent from hundreds of additional offshore islands, although many are considered likely to have stoats or be within reach of them.

Because the stoat is self-dispersing rather than depending on man for transport, it is possible to predict which islands stoats may already have reached, or those under threat of future colonisation. It is clear that stoats regularly emigrate to islands up to 800 m offshore, and sometimes even to 1100 m. On present experience, islands 1200 m or more offshore appear safe.

In predicting the likelihood of stoats reaching an island it is important to remember that the limiting isolating factor of 1200 m refers to the widest gap to be swum. If other islets act as stepping stones then stoats clearly could reach islands much more distant. Also very important are the prevailing sea conditions and tidal currents in an area; an exposed water gap is a far more effective barrier than one of similar distance in a sheltered bay. For instance, Breaksea Island in Fiordland is still free of stoats, although the largest water gap between it, adjacent islets, and stoat-infested Resolution Island is only 1000 m. But in this locality the coasts are exposed and seas are seldom calm for long.

Using the proposed maximum swimming range of 1200 m, the number and proportion of offshore islands (of over 2 ha) safe from stoats differs markedly in various regions of New Zealand (Fig. 5). The Northland/Hauraki region

Table 4: *New Zealand offshore islands* (> 2 *ha* in *area) known to be colonised or visited* by *stoats*. (*Unpublished file repon).

	Island	Lat. S	Long. E	Area (ha)	Water crossing (m)	Source of stoat record
1	Waewaetorea	35º12'	174º13'	41	300	Hitchmough & McCallum, 1980.
2	Moturoa	35º13'	174º10'	146	250	Johnson, 1978, unpubl.*
3	Urupukapuka	35º13'	174º14'	209	600	Hitchmough & McCallum, 1980.
4	Motuarohia	35º14'	174º10'	58	1,000	Owen, 1978, unpubl.*
5	Motuoruhi	36º45'	175º24',	70	750	Newhook *et al*., 1971
6	Waiheke	36º46'	175º08'	9,459	1,100	Marshall, 1963
7	Ponui	36º52'	175º11'	1,851	1,100	Bellingham, 1979
8	D'Urville	40º50'	173º51'	16,782	500	Buckingham & Elliott, 1979, unpubl.*
9	Forsyth	40º58'	174º0.4'	775	300	Taylor & Wilson, 1979, unpubl.*
10	Adele	40º59'	173º0.4'	87	800	Present study
11	Fisherman	41º00'	173º0.3'	3.6	700	Present study
12	Maud	41º01'	173º53'	30.9	900	Bell, 1983
13	T awhitinui	41º03'	173º48'	22	400	Gaze, 1982, unpul.*
14	Pickersgill	41º10'	174º17'	103	300	Gaze, 1981, unpubl.*
15	Blumine	41º11'	174º14'	400	400	Bell & Roderick, 1963, unpubl.*
16	Arapawa	41º11'	174º19'	7,785	700	Taylor, 1981, unpubl.*
17	Secretary	45º13'	166º54'	8,140.	650	K. Morrison, pers. comm.
18	Resolution	45º40'	166º35'	21,300	600	Wodzicki & Bull, 1951
19	Elizabeth	45º25'	167º07'	74	150	P. Brotherston, pers. comm.
20	Whidbey Point	45º41'	166º32'	4.6	200	Morrison, 1979, unpubl.*
21	Cooper	45º45'	166º50'	1,886	200	Morrison, 1979, unpubl.*
22	Anchor	45º46'	166º31'	1,525	800	K. Morrison, pers. comm.
23	Small Craft Harbour	45º58'	166º39'	48	500	P. Brotherston, pers. comm.
24	Chalky	46º03'	166º31'	475	1,100	Veitch et al., 1973, unpubl.*
25	Weka	46º06'	166º42'	108	700	K. Morrison, pers. comm.
26	Coal	46º07'	166º30'	1,622	400	K. Morrison, pers. comm.

is well endowed in this respect with 74% of its numerous islands seemingly outside the reach of stoats. The Bay of Plenty and Cook Strait regions have fewer islands of which 78% and 47%, respectively, are safe. In distinct contrast, Fiordland has only one of its many islands isolated by more than 1200 m of water and all others are threatened. Stewart Island, with no stoats, is a special case - but should stoats ever be taken there, about 50% of its offshore islands would be at immediate risk.

Table 5: *The accessibility of 65 New Zealand islands* (>2 *ha* in *area and (< 5000m offshore)* on *which the status of stoats is known.*

Water crossing (m)	Number of islands	Islands with stoats	% with stoats
0- 0.0.	10.	10.	100.0.
40.1 - 80.0.	11	11	100.0
80.1 - 120.0.	12	5	41.6
120.1 - 160.0.	10.	0	0.0
1600+	22	0	0.0

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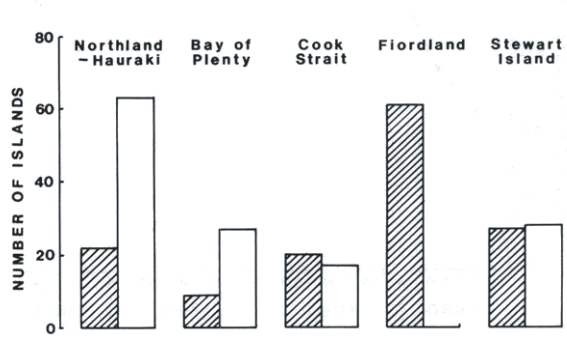

Figure 5: *Geographical distribution of offshore islands* (>2 *hay* showing *number of islands* in *each* region within *(hatched column) and beyond (unhatched column) the* proposed *maximum* swimming *range (1200 m) of stoats*.

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