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EVIDENCE OF PREDATION BY KIORE UPON LIZARDS FROM THE MOKOHINAU ISLANDS

Summary: The kiore or Polynesian rat *(Rattus exulans)* has been suggested as the probable cause for reduced reptile, seabird and invertebrate faunas on many of the northern offshore islands of New Zealand, but the evidence is largely circumstantial and it is based on comparisons between islands with and without kiore. In 1977, kiore colonised a small island in the Mokohinau Group (Hauraki Gulf), where they caused a dramatic drop in lizard numbers. Their impact upon seabirds appeared minimal. Kiore were subsequently removed by poisoning; the altered lizard fauna remaining suggests that some species were more susceptible to rat predation than others.

Keywords: *Rattus exulans*; Mokohinau Islands; rat invasion; reptile predation; seabird nesting; rat removal; altered fauna.

Introduction

The kiore or Polynesian rat, *Rattus exulans* (Peale), is widespread throughout the Pacific region, inhabiting most of the island groups within 30° latitude of the equator, and present as far south as latitude 47° in Fiordland and Stewart Island, New Zealand (Williams, 1973). Its presence on widely separated island groups has been attributed to transportation, deliberate or accidental, during Polynesian colonisation of the Pacific. Subfossil evidence suggests the kiore arrived with the early Maoris around 1000 AD (Millener, 1981). .

Whitaker (1973, 1978) showed that lizard faunas were less diverse on those islands off northern New Zealand occupied by kiore, and that most species recorded on kiore-inhabited islands are either present only in small numbers, or are in habitats which provide refuge from kiore (e.g. cliffs, boulder beaches). Several species of *Cyclodina* occur chiefly on rodent-free islands, and are extremely localised on the mainland. Whitaker (1973, 1978) interpreted this distribution as relict, resulting from virtual extinction on the mainland and many offshore islands within the last 1000 years, since the introduction of mammalian predators (chiefly rodents).

Imber (1975) reviewed the effects of introduced predators, mainly rats, upon nesting seabirds, and concluded that a seabird is endangered "by a species of rat whose maximum weight approaches or exceeds the mean adult weight of the petrel. This is probably because the smaller the petrel relative to the rat, the longer will be the period of vulnerability of chicks to rat predation". Small seabirds such as diving petrels *(Pelecanoides urinatrix)* (125 g) and white-faced storm petrels *(Pelagodroma marina)* (50 g) rarely breed on islands with kiore (maximum weight 130 g).

Evidence for kiore damage to reptile and bird populations is largely circumstantial, and alternative explanations for impoverished faunas have been presented. For example, Craig (in press) suggests depauperate faunas are at least partly the result of habitat modification associated with human activity, and questions the assumption that lizard distribution on offshore islands was uniform prior to the arrival of kiore.

Most islands with kiore are characterised by human disturbance, including fire, browsing by stock and introduction of cats. Opening of the forest cover allows increased predation on lizards by birds such as kingfishers *(Halcyon sancta)* and blackbirds *(Turdus merula)*. Kiore populations commonly fluctuate to a greater extent where habitats have been altered, especially where grasslands are established. This is presumably due to the seasonal availability of grass seed, an important item in kiore diet. Craig (in press) suggests that potential damage by kiore to the flora and fauna is greater on islands where seasonal grass seeding causes marked population cycles than on those with more diverse forest communities.

Kiore colonised Lizard Island, Mokohinau Group (outer Hauraki Gulf) in the mid 1970s, and were subsequently removed by poisoning. Studies of lizard and bird populations before, during and after the kiore occupancy provide direct evidence of the effects of kiore on an offshore island's fauna.

Study Area

Lizard Island (0.8 ha) is a low-lying island of eroded rhyolite and one of the smaller members of the Mokohinau Group (35°50'S, 175°10'E). Horokaka *(Disphyma auslrale)* and glasswort *(Salicornia australis)* occur around the shore margins, while taupata *(Coprosma repens),* ngaio *(Myoporum laetum)* and hymenanthera *(Melicytus novae-zelandiae)* form a 1-2 m canopy over the centre of the island.

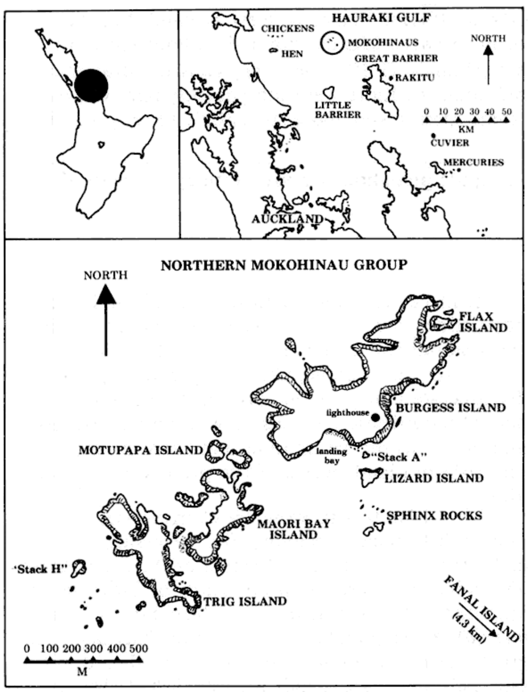

Figure 1: *The Mokohinau Islands, showing their locality in the Hauraki Gulf and the position of Lizard Island. The distance to Fanallsland is from Sphinx Rocks.*

There is no evidence of disturbance on Lizard Island during Maori or European occupation of the Mokohinau Group (Fig. 1). Most of the other Mokohinau Islands have been extensively modified. Burgess Island (52 ha) is mainly grassland with some herbaceous cover. It was the site of a manned lighthouse from 1883 to 1980, when livestock were removed, buildings destroyed and the ligllt automated. The islands west of Burgess Island are known as the Knights Group (including Maori Bay, Trig and Motupapa Islands and several smaller stacks), and these were burnt annually by muttonbirders and occasionally by fisherman prior to 1932. Trig Island was grazed by goats during the early 1940s. Muttonbirders still visit the Knights Group during November to collect young grey-faced petrels *(Pterodroma macroptera).*

The presence of kiore on islands can be attributed to transport by humans, either as food or accidentally, but they are also found on many islands too small for human occupation. Whitaker (1974) showed that kiore can swim distances up to 130 m and survive as long as 17 minutes in the sea; they could therefore colonise small stacks and islets once introduced to any of the larger Mokohinau Islands.

Kiore are present on most islands of the Mokohinau Group, including Burgess Island which is only 100 m from Lizard Island. However, kiore appear to have been absent from Lizard Island until 1977 (C.R. Veitch, pers. comm.), when they colonised, either by swimming from Burgess Island by way of "Stack A" (Fig. 1), or as a result of accidental introduction. Poisoning was carried out in May 1978 (C.R. Veitch, pers. comm.).

Methods

Details of the seabird and lizard fauna of Lizard Island prior to the invasion by kiore are taken from reports of a Wildlife Service expedition to the Mokohinau Group in November-December 1973, (Whitaker, 1974, 1978 and unpubl.; Veitch, 1973). Records of lizards were obtained from six pitfall traps set in taupata baited with tinned fruit for a total of 11 days, and from three searches by day and night. Information on seabirds, recording the contents of burrows (eggs, chicks or adults) and birds visiting the island at night, was collected during similar searches.

Subsequent to kiore colonisation, the bird, lizard and rat faunas of Lizard Island were surveyed in May 1979 and December 1983-January 1984. In May 1979, a single day was spent on Lizard Island and all suitable habitats were carefully examined for kiore, lizards and seabirds. During the December 1983-January 1984 survey, four landings were made on Lizard Island and 10 pitfall traps baited with petfood were set for lizards (five on iceplant and low ngaio at the north-western corner of the island and five in glasswort along the south-eastern side of the island). Two timed searches for lizards were made by day and a third at night. Timed searches on other islands in the group were also made by day and night. Only lizards counted during timed searches are included within the results; other lizards were captured or seen outside of these searches.

Results

Fauna of Lizard Island prior to rat colonisation

Allied shearwaters *(Puffinus assimilis)* and white-faced storm petrels, both of which appear to be sensitive to rat predation, dominate the seabird fauna of Lizard Island. Sandager (1890) reported that the white-faced storm petrel "breeds in considerable numbers, the nests being as close together as the ground will permit" on Lizard Island. Allied shearwaters were present in smaller numbers.

In November-December 1973 nesting white-faced storm petrels were found to be "common", with a "few" allied shearwaters and diving petrels breeding; fluttering shearwaters *(Puffinus gavia)* were recorded ashore but nesting was not confirmed (Veitch, 1973).

The first detailed survey of the reptile fauna of Lizard Island was in November 1973 (Whitaker, 1974, 1978 and unpubl.), when *Hoplodactylus pacijicus, Leiolopisma moco, L. smithi, L. suteri* and *Cyc/odina aenea* were recorded. The results of three timed searches and catches from pitfall traps during November 1973 are given in Table I.

Table 1: *Lizard abundance on Lizard Island in November* 1973 *(A.H. Whitaker, pers. comm.) and January* 1984.

	Timed searches (lizards/hour)		Pitfall traps (lizards/10 trap-days)	
	1973 (total 101 minutes)	1984 (total 175 minutes)	1973 (total 66 Trap-days)	1984 (total 66 Trap-days)
H. pacificus	32.7	1.0	0.76	0.2
unidentified gecko	11.3	-	-	-
L. moco	0.6	0.3	1.36	-
L. smithi	0.6	-	-	-
L. suteri	5.9	1.0	0.15	-
C. aenea	0.6	-	-	-
Total lizards	51.7	2.4	2.3	0.2

Fauna of Lizard Island after rat colonisation

Attempts to remove kiore from Lizard Island with poison laid in May 1978 (C.R. Veitch, pers. comm.) were apparently successful; neither rats nor fresh rat sign were seen during visits in May 1979 and January 1984. The only indication that kiore had been present was a skull found near the summit in 1979.

In May 1979, white-faced storm petrel burrows covered much of the upper part of the island. Although burrows were empty (breeding season is October-March), a number contained small, empty white eggs shells, indicating that birds had bred in previous seasons; broken shells present could denote either hatching of chicks or predation of kiore. Allied shearwaters were found in burrows by day, but no eggs had been laid (the birds occupy burrows in April, lay in May and most chicks fledge by early summer).

No lizards were found during a 90 minute visit to Lizard Island on 21 May 1979, despite careful searching.

Fauna of Lizard Island following removal of rats

A more intensive study of the wildlife of Lizard Island was made in December 1983-January 1984; the abundance of lizards is summarised in Table 1 and comparisons of surveys on other islands are given in Table 2.

White-faced storm petrels were abundant on Lizard Island during January 1984. The surface of the plateau was honeycombed with small narrow burrows, most of which contained a chick. On the night of 2 January, several hundred adults were seen flying around the summit of the island.

Fledgling allied shearwaters were also common; many burrows contained young with down on their backs and developing feathers on the face, wings and underparts. Culmen measurements and plumage colouration confirmed their identification; most young allied shearwaters normally leave their breeding grounds by late October. Many other burrows of a size characteristic of allied shearwaters were empty, but showed signs of recent use. Several dozen adult allied shearwaters were flying around the summit of Lizard Island at night.

Two dead adult diving petrels were also found on Lizard Island in January 1984. Of the few dead seabirds noticed around the colonies on the island, none showed signs of predation. The many young allied shearwaters and white-faced storm petrels seen show it was very unlikely that kiore were present.

No iizard species was common on Lizard Island during the surveys of January 1984. *H. pacificus* were caught in glasswort around the edge of the island and under loose rocks, a single *L. moco* was seen running through grass and *L. suteri* were found along the northern side. Neither *L. smithi* nor *C. aenea* were located.

Comparison with lizard surveys on other islands

Table 2 compares the abundance of lizards on Lizard Island in 1973 and 1984 with results from other islands in the Mokohinau Group and shows that their

Table 2: *Lizard density in the Mokohinau Group, November 1973 (A.H. Whitaker, pers. comm.) and January 1984. *Kiore were absent on Lizard Island during the surveys of 1973 and 1984 and were present only for a short period (nUnwinu thpir arrival in 1977 until their removal bv poisoning during 1978.*

Island	Area (hectares)	Kiore	Lizards found per hour during timed searches		
			1973		1984
"Stack H"	1.2	absent	121.9		50.5
Maori Bay	10.0	present	15.2	various parts of island	6.4
Burgess	52.0	present	6.0 11.0 16.2	various Parts of island	5.3
Lizard	0.8	*	51.7		2.4
Trig	16.0	present	6.7		not searched
Flax	1.3	present	0	(search time 45 minutes)	0 (search time 45 minutes)
Fanal	75.0	present	0	(search time 85 minutes)	not searched
Sphinx Rocks	0.2	absent	no data		1.5
Stack "A"	0.04	absent	no data		0 (search time 20 minutes)

abundance in 1973 was second only to "Stack H", which is of a similar size, undisturbed by humans and without kiore. Following the invasion by kiore, the lizard fauna of Lizard Island declined in abundance from second to fourth by 1984.

Discussion

Differences in the seabird and reptile faunas of Lizard, Island prior to and following rat colonisation reflect the different sensitivites of the species to predation and their ability to recover once rats were removed.

The decline of lizards on the island is most apparent. Capture rates for pitfal. trapping declined from 2.3 lizards/10 trap-days in 1973 to 0.2 lizards/10 trap-days (Table 1) by 1984 (although there were' seasonal and technical differences between the two trapping periods). Five lizard species were recorded in 1973 (Whitaker, 1974) but only three in 1984 when the overall density had fallen (Table 1). The records for November 1973 and January 1984 must be interpreted with caution because of differences in observers, weather and seasons. It is, however, valid to compare the changes in relative abundance of lizards on various islands before and after the colonisation of Lizard Island by kiore.

The drastic effects of kiore on the lizard population may be due both to direct predation and competition for food supplies, as it is likely that the kiore population reduced - and perhaps locally exterminated - populations of some invertebrates formerly eaten by the lizards. Recolonisation by the invertebrates is likely to be slow, especially for those species with poor powers of flight. This may also contribute to the slow recovery of the lizard population, already hampered by their low recruitment rates.

The small size (0.8 ha) and lack of habitat diversity on Lizard Island mean there are few refuges, such as cliffs or boulder beaches, where kiore predation on lizards would have been minimised. Small spaces between boulders restrict rat movement yet provide suitable habitat for lizards, while steep cliff faces often support moderate numbers of geckos.

In contrast, the seabird fauna of Lizard Island was apparently little affected by the colonisation of kiore. Unlike the lizards, which were in year-round contact with kiore, the seabirds coexisted with the rats only for the duration of their 3-5 month breeding season. Kiore may be capable of killing both adult and juvenile storm petrels, but predation of adult allied shearwaters is unlikely, although young chicks may be vulnerable.

The breeding of numerous white-faced storm petrels and allied shearwaters on Lizard Island during January 1984 suggests that these species are able to survive in the presence of kiore for short periods, although stable colonies do not occur on kiore-inhabited islands. It is probable that kiore may have affected seabird recruitment in the period they were ashore (approximately one season until mid-1978), but this was not sufficient to seriously modify the population. The difference between the effects of kiore on seabirds and those on the lizards may be attributed to several factors: i) rat predation was limited to the period when birds were ashore for the span of their breeding season; (ii) adults are less vulnerable than chicks or eggs; and (iii) a sizeable proportion of the seabird population consists of non-breeding juveniles which spend the years between fledging and nesting at sea, thus forming a reserve of potential breeders in seasons following the removal of kiore. In addition, the kiore population may have been at low numbers during the winter when prey was scarce, but could not increase rapidly enough to inflict massive predation when young seabirds were available. By the end of the seabirds' nesting season, however, kiore numbers could have increased and this would have accentuated predation on lizards and invertebrates once the birds had fledged.

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