are less prominent at Kaikoura. They usually breed close to the gulls on patches of gravel and sand where their nests are hard to find and almost impossible to count. Bell (pers. comm.) estimated 2000-2500 nests in 1957 and 1958; I estimate that not more than 1500 pairs nested in 1962 and 1963. White-fronted terns often feed close inshore in small flocks, but larger flocks fly out to sea in the mornings and return at sundown. They probably feed among the gull flocks. Courting birds sometimes carry silver fish 5-7 cm. long in their beaks; food species have not been identified. Black-backed gulls *(Larus dominicanus)* roost on the reefs in winter, usually in small flocks totalling 100-150 birds. They feed intertidally and scavenge about the fish quays. In summer this species becomes less prominent; only two or three pairs are believed to breed on the peninsula, but Riley's Rock supports about 100 nests (Bell, pers. comm.). Caspian terns *(Hydroprogne caspia)*, black-billed gulls *(Larus bulleri)*, Arctic skuas *(Stercorarius parasiticus)*, and southern skuas *(Catharacta skua lonnbergi)* are occasional visitors. About 20 pairs of black-billed gulls nested among red-billed gulls on the peninsula in 1964. None of their chicks survived.

## SUMMARY

This paper describes the Kaikoura peninsula and neighbouring coastline and draws attention to the rich fauna of sea birds, seals and dolphins centred in the area. Local water movements are summarised, and information given of persistent fish shoals, large dolphin schools, inshore whale movements, and the extensive feeding range of Kaikoura's red-billed gulls, from reports contributed by commercial pilots. An annotated list of sea birds is presented.

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# NOTES ON THE 1964 ERUPTION AND THE VEGETATION OF RAOUL ISLAND

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The sudden eruption of the Raoul Island volcano on 21 November 1964 abruptly terminated the Ornithological Society of New Zealand's* Expedition to the Kermadecs which had arrived only two days previously. The following observations are mostly little more than general impressions gained by the writer who was the botanist to the Expedition. The parts of the island visited were the north and east sides and the central crater area.

Raoul Island is the largest of the Kermadec group and lies just south of latitude 20° 15′ S. and east of longitude 178°W. Thus it is on the fringe of the subtropical region and has a mean annual temperature which averages 19.0°C. Rainfall averages 59 inches per annum and is fairly well distributed. The total area is 7260 acres, of which nearly half is occupied by the large central caldera, in the bottom of which are three lakes. The whole island is of volcanic origin, and the andesitic rock, often overlaid with pumice, has generally resulted in a very rugged surface. The highest point, Moumoukai peak, is just under 1700 feet, and forms part of the mostly steep-sided rim of the caldera.

Raoul does not seem ever to have had a permanent Polynesian settlement. After serving as a rendevous for whalers in the early 19th century, a number of attempts at settlement were made by Europeans during the

* I acknowledge with gratitude the opportunity to visit Raoul Island given me by the Council of the New Zealand Ornithological Society, and the assistance from members of the Kermadec Expedition.

following years. There is no permanent settlement now but a meteorological station near Fleetwood Bluff on the north side is continuously manned.

The most obvious points of interest concern the effect of the eruption upon the vegetation. During the day preceding this event the water in the Green Lake was rising and becoming hotter; and where volcanic activity was most obvious the water temperature was about 50°C. and was therefore killing the vegetation. This process must have been happening quickly because in cooler parts of the lake a number of species, particularly ferns, had been completely submerged, but at the time were not yet showing any ill effects.

The fern *Nephrolepis exaltata* (L.) Schott. growing at the lakeside and near existing fumaroles was being killed by the rising steam and hot water. The preference of *Nephrolepis exaltata* for thermal areas is well-known (e.g. Cockayne 1928), and its abundance around the Green Lake has been especially linked with the long-established fumaroles. However, just above the western side of the Green Lake where there was a fairly level terrace running to the crater wall, this fern was not occupying the places first affected by the recent heating of the ground from below. This suggests that such areas, often in slight depressions, had been heated in recent years, probably in periods of increased fumarole activity. Apparently the ground in these places near the fumaroles had been fairly recently colonised, because open communities were still often present. All the species were weedy exotics which were common on disturbed ground, notably members of the Gramineae, Cyperaceae and Compositae. I particularly noted *Sporobolus capensis* Kunth., *Setaria lutescens* F. T. Hubb., *Kyllinga brevifolia* Rottb., *Hypochaeris glabra* L., *Bidens pilosa* L. and *Ageratum conzyoides* L. The clubmoss *Lycopodium cernuum* L. was also quite common here. There were differences in tolerance to the increasing heat. *Ageratum conzyoides*, a plant with relatively large hairy leaves, seemed to be the first to show the effects of the heating up of the substratum. Small pohutukawa trees (*Metrosideros kermadecensis* Oliver) standing in the rising hot water near the edge of the lake appeared unaffected, whereas similar-sized specimens of ngaio (*Myoporum laetum* Forst. f.) were showing obvious signs of distress with leaves wilted and already turning brown.

The initial eruption seemed mainly to consist of huge clouds of steam several thousand feet high, amongst which were blackish columns of ash and mud, ejected from the newly formed crater(s) in and around the Green Lake. About half an hour later a visit to the lower northern rim of the crater disclosed extensive damage to the vegetation around the Green Lake. This damage extended over to the leeward side of the small ridge connecting the Blue and Green Lakes, i.e. to the side facing the observation point on the north side of the crater, and it seemed to have been mainly occasioned by blast, since although there was no sign of smoke or flames, the trees, mainly pohutukawa, had been completely stripped of twigs and small branches as well as of the leaves. The grey appearance of this devastated forest suggested that ash and/or mud must have fallen as well. Observers at a higher vantage point said that nearer the fresh vents large stands of trees had been partially blown over and their trunks aligned in one direction; this was obviously blast effect again. It would be interesting to observe how much of the damaged vegetation recovers.

I could not assess the extent of the ash shower resulting from the eruption, but the finer ash was carried on the north-easterly wind blowing during the day of the eruption. Members of the Expedition working in Denham Bay at the time first noticed ash or mud fall-out at the southern end of the bay at about 11 a.m., 5 hours after the initial eruption. Observations from H.M.N.Z.S. *Lachlan* two days later showed that much of the pohutukawa forest on this outer south-west side of the crater was covered with a powdering of dried ash or mud. The original grey of the newly fallen wet material had become much lighter, so that, towards the rim of the crater especially, the trees looked as if they had a light powdering of snow. Inside the main crater much of the vegetation probably received some ash fall-out.

This suggests that the eruption may have followed a similar pattern to that of 1814, as described for the first Rangitahua ash shower on Raoul by Wright and Metson (1959). The damage around the Green Lake as described above seems comparable with that reported from the 1872 eruption, the last one prior to the present (Wright & Metson 1959). Presumably blast, steam and hot ash all played a part, either separately or in combination.

## OTHER OBSERVATIONS ON THE VEGETATION

The endemic euphorbiaceous *Homalanthus polyandrus* (Hook.f.) Cheeseman was seen in several localities, especially in the gullies behind the Meteorological Station on the northern side of Raoul Island. Isolated specimens were noted between the Station and Fishing Rock, whilst others were reported from the road to Boat Cove on the eastern side. Thus it seems that Oliver's (1910) pessimism about the future of this species has not so far been justified, since it is apparently still as common as in 1908. Another notable endemic belonging to the tropical or Malaysian element is *Boehmeria dealbata* Cheeseman, a shrubby member of the Urticaceae. Scattered large shrubs of this species were seen on the northern side of the island. *Homalanthus* especially was said by Oliver (1910) to be heavily browsed by goats, and in view of the obvious signs of their presence in considerable numbers, both species are probably still being checked by them. Flowers of both species were seen, but only one seedling *Homalanthus polyandrus*. The two endemic coprosmas, both allied to New Zealand species, are still present although probably not abundant. *Coprosma petiolata* Hook.f. seems to be the commoner of the two. The odd specimens of *C. acutifolia* Hook.f. found in disturbed forest were attractively laden with bright orange fruits, whereas no flowers or fruits were seen on *C. petiolata*. The gay appearance of *C. acutifolia* when in fruit was noted by Oliver (1910).

The introduction of exotic plants and animals to Raoul Island has resulted in considerable changes to the vegetation, although apart from the areas of settlement near the north coast and in Denham Bay most of the dominant species are still native plants, *Metrosideros kermadecensis* being the most important. The introduction of exotic plants must have begun with the early Polynesian voyagers and Oliver (1910) firmly concludes that the presence of *Cordyline terminalis* Kunth. indicates this. This species appears to be reasonably common in the open forest areas on the north side. The advent of Europeans soon produced a big extension of the introduced flora so that Cheeseman (1888) could list 26 species introduced as a result of European ships calling, as well as of actual European settlement. Of this list 23 are common temperate European weeds, one is a temperate North American weed widely naturalised in Europe, and only two, *Physalis peruviana* L. and *Cynodon dactylon* Pers., can be described as of tropical or subtropical origin. Many, if not all, the species on this list are still on the island, but the immediate impression is that tropical or subtropical species form a far greater proportion of the total. However, Cheeseman believed that certain exotic weeds which are common to many tropical and subtropical countries were actually native to the Kermadecs, although these and others not recorded by him must have spread greatly since the late 19th century.

One obvious introduction, commented on by all recent visitors but not mentioned by Oliver (1910), is the abundant large aroid, *Alocasia macrorrhiza* (L.) Schott. This species is a native of the Indian sub-continent and on Raoul Island often fills damp gullies with a lush vegetation about five feet high. It spreads partly by means of the stout rhizomes but may also be distributed by seed for it flowers so copiously that in sheltered areas it scents the air. The marginal terraces of the crater lakes were invaded by this aroid although it was there generally a smaller plant. It must be unpalatable to goats but pigs were uprooting it near the Meteorological Station. Details of the introduction of this species are not known to the writer, but it is a well-known plant today in many tropical islands of the Pacific and may also be found in some New Zealand gardens, especially in the Auckland area. It was very likely introduced from Niue Island, since in the late 19th century Mr. T. Bell employed a number of people from that island (Morton 1964). It is common on Niue Island but is regarded as a source of food only in times of shortage (Yuncker 1943).

*Ageratum conzyoides* L., an almost ubiquitous weed in tropical and subtropical countries, was listed as a native by Cheeseman (1888), but was recognised as an exotic by Oliver (1910) who noted its abundance in several parts of Raoul Island. The spread of this blue-flowered annual composite must have continued, because there seems to be hardly a disturbed piece of ground, except in deep shade, where it does not thrive. Mention has already been made of its presence near the Green Lake and it was growing in almost boggy conditions around the Blue Lake. On the other hand it is very common on dry, steep cliffs and near the shore. Oliver suggests that goats have played a part in spreading this species.

The woody plants have not run wild to the same extent as some herbaceous species and only one of those mentioned below was recorded by Oliver (1910). This doubtless merely reflects the nature of the species which happened to have been brought in. Those present were introducd for the purpose of cultivation, either for ornamental reasons or for food. Among the latter is the guava (*Psidium guajava* L.), which has obviously been planted around the original homestead of the Bell family near the present Meteorological Station, but has now spread to the shores of the Blue Lake. Another fruit which could have been carried by birds or accidentally distributed by man is *Passiflora edulis* Sims. This species is scrambling over large shrubs and small trees in an area above Low Flat. One of the commonest ornamental shrubs in the region of the Meteorological Station is *Cassia corymbosa* Lam. agg., which seeds prolifically and is spreading along the roadside, especially in more shady parts. In the same family is what appears to be a species of *Caesalpinia*, reported as forming large thickets in Denham Bay. Unfortunately, I was unable to obtain adequate material of this plant. The shrubby *Catharanthus roseus* G. Don (syn. *Vinca rosea* L.) is recorded by Oliver (1910) for Denham Bay and still persists there. It is perhaps not out of place here to warn against the danger of indiscriminately introducing certain other sub-tropical ornamental shrubs. Two obvious examples are the verbenaceous *Lantana camara* L. and *Duranta repens* L. These are reasonably well-known garden shrubs of northern areas of New Zealand. They are both spiny and have a bad record of invading many areas of the Old World into which they have been introduced.

A final observation concerns the well-known stand of Norfolk Island pine (*Araucaria excelsa* R. Br.), planted by the Bell family near their house and forming

a prominent land-mark just west of the present Meteorological Station. Norfolk Island pines are common in many coastal districts of New Zealand, of course, but mature cones are rarely produced. On Raoul, several trees had formed numerous cones which seemed to be fully grown. Raoul Island and Norfolk Island are on the same latitude, but this probably does not explain why the species usually fails to form viable seed in New Zealand.

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# WINTER ECOLOGY OF THE PARTRIDGE (*PERDIX PERDIX*) IN THE CANADIAN PRAIRIE

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Of the higher vertebrates living in northern regions of the Northern Hemisphere, birds have a pronounced advantage over mammals in their facility for escaping winter through flight to warm southern climates. Very few birds stay behind when southern migration transfers the vast bird populations to suitable wintering grounds.

In North America more birds are found in winter in the boreal forest (the northern coniferous forest or taiga) than in the prairies to the south. The forest provides more food and shelter and various groups are present such as grouse (Tetraonidae), woodpeckers (Picidae), titmice (Paridae) and others.

FIGURE 1. *Prairie farmland in the Aspen Parkland zone in northern Alberta and Saskatchewan, just south of the boreal forest and the northernmost extensions of the partridge range in North America. Early April 1962.*

The boreal forest gives way southwards to the prairie through an ecotone, the Aspen Parklands, dominated by aspen poplar *(Populus tremuloides)*. Settlement northward from the prairies has appreciably opened up the aspen parklands (Fig. 1), and it is in this zone and in farmland districts cleared in the boreal forest immediately to the north of it that the partridge is found at the northernmost extension of its North American range.

From liberations near Calgary, south-western Alberta, in 1908, partridges spread rapidly north-east and south and now occupy practically all of the Canadian prairie as well as the aspen parklands. Along roads, clearings and settlements penetrating into the boreal forest, small partridge populations are also present.

## THE PRAIRIE WINTER

The Canadian prairie, forming the vast habitat of the partridge, measures some 900

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