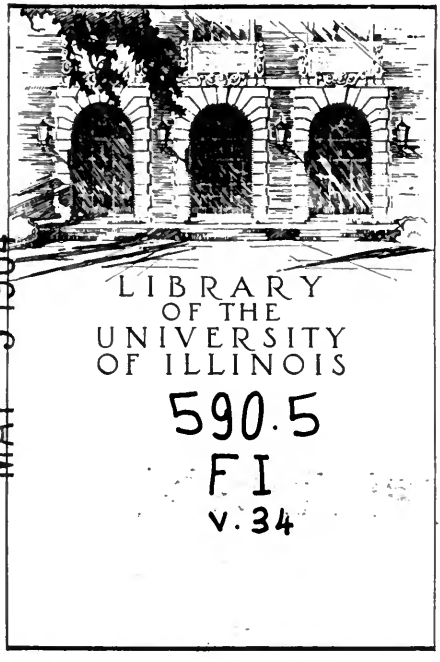

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A VISIT TO KAREWA ISLAND, HOME OF THE TUATARA

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The Mesozoic age bequeathed to our modern world only five of its many kinds of reptiles. In the new world of mammals and birds the lizards and snakes found niches in which they could not only persist but could flourish, and there are some two thousand species of each. The three other groups—the turtles, the crocodilians, and the tuatara—are relicts, mere remnants, of the great age of reptiles. There are about two hundred species of living turtles, and these are so remarkably diverse that they give us a reasonable picture of the whole order. The turtle group arose before the dinosaurs and have persisted as long after their extinction. Related to the dinosaurs, and affording us here and there a glimpse of what the saurian age must have been like, are the crocodilians, with only twenty-two living species. Even this is a wealth of species compared to that relict of relicts, the tuatara, whose Triassic relatives are as ancient as the turtle group and whose one species is confined to New Zealand. For the past hundred years it has been extinct on the main islands of New Zealand; but populations of the lizard-like creature have preserved themselves on offshore islets and there enjoy the protection of the New Zealand government. At last listing (Falla, 1935), the tuatara was known to occur on thirteen small islands off the New Zealand coasts. The tuatara (*Sphenodon punctatus* Gray) was described as a lizard; but examination of its anatomy enabled Albert Günther to recognize it in 1867 as a distinct order, a relative of the otherwise long-extinct order of Rhynchocephalia. No Tertiary fossils of this group of reptiles are known, and the extinct Triassic forms were described before the tuatara became known in Europe; of all reptiles, therefore, it most deserves the term "living fossil."

One of the best known of the island sanctuaries of the tuatara is Karewa Island, an islet in the Bay of Plenty some seven miles out

from the entrance to Tauranga Harbor. Karewa rises as a sharp triangular peak some 300 feet above the sea, from a platform about 1,000 by 500 feet. Its total area is about nine acres, which I have reckoned at 3.5 hectares for purposes of estimate. Except for the very top, the nearly vertical parts of the northern and eastern aspects of the island, and the wave-washed boulder zone at the shore-line, the island is clothed with vegetation. Karewa is of interest for its nesting sea birds as well as for its tuatara population. Its surface is honeycombed by the burrows of the vast nesting colony of large petrels, more properly the flesh-footed shearwater, *Puffinus carneipes*, one of the "mutton birds" of the New Zealanders. The burrows of the shearwaters are shared by the lizard-like reptile. The island has been well described by Sladden (1924) and was visited by Dr. and Mrs. Robert Cushman Murphy[1] in 1948. As for the tuataras, Karewa Island is the type locality. The type specimen in the British Museum is labelled "Karewa Island, Bay of Plenty," and Ernst Dieffenbach, the collector, writes of Karewa in 1843 as the only locality known to him for this then strange reptile.

My visit to Karewa was to see the tuatara in a natural environment. The details of the trip were arranged by Mr. E. G. Turbott of the Auckland Museum, and the final leg of the journey was made possible by the friendly co-operation of Mr. Percy F. Carter, of Tauranga.[2] Landing by dinghy from Mr. Carter's ketch, the *Raumatu*, was not without difficulty, for tumbled rocks fringe Karewa, but the encrustation of barnacles afforded secure foothold. With canvas and sleeping bag supplied by Mr. and Mrs. Turbott, and with water and bread and cold meat and cheese calculated to serve for a two-night stay, I was landed at 7 o'clock P.M. on January 26, 1949. I then worked my way over the area of spray-washed boulders (from three or four to 15 or 20 feet in diameter) to the soil zone, some twenty feet above the sea, where vegetation meets the boulders, and found a place for my bed on soft soil beside a giant rock. The upper boulders are quite covered with an encrustation of yellowish and reddish lichens, which, on the landward faces of the larger rocks are replaced by dense gray foliaceous forms.

Above the fringe of boulders the more gentle slopes to the south and west are covered with a blanket of reddish soil, which supports a low forest made up almost exclusively of a coprosma, *Coprosma*

[1] I am indebted to Dr. Murphy for the enlargements from motion picture film used herewith as illustration.

[2] I am now further indebted to Mr. Carter for photographs of Karewa from the sea.

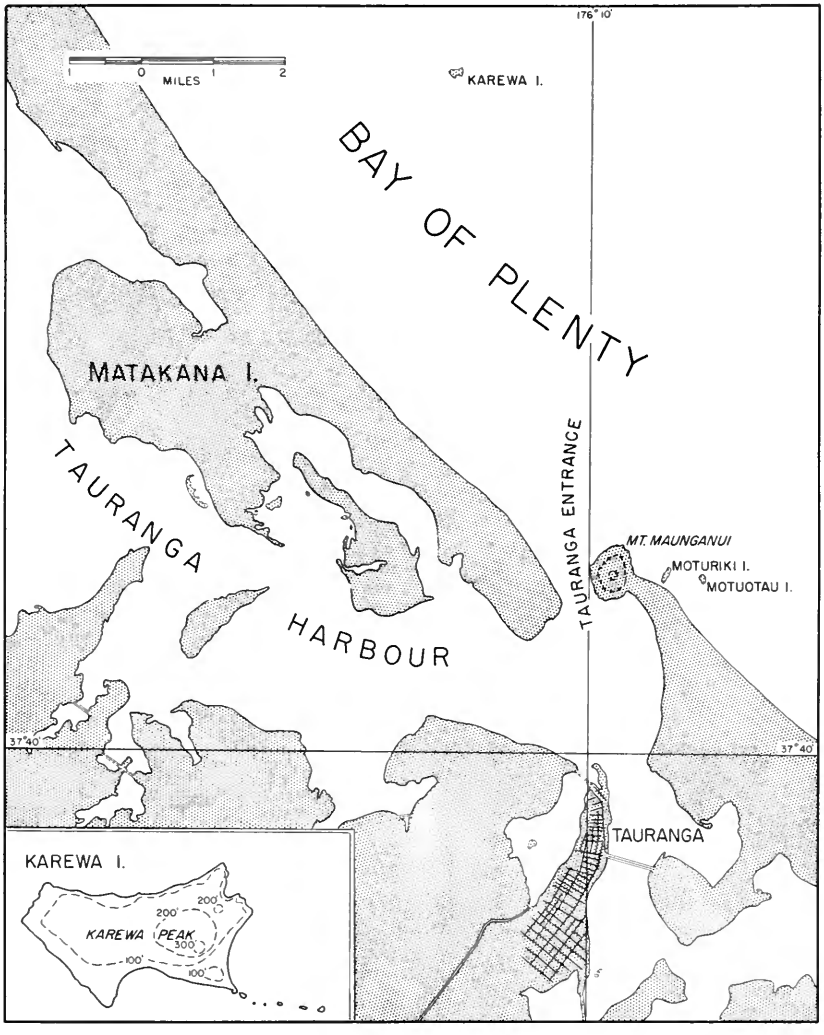

FIG. 28. Location of Karewa Island in Bay of Plenty, North Island, New Zealand. Outline of Karewa from map of New Zealand Land Survey. Contours on Karewa drawn from photographs supplied by Percy F. Carter, of Tauranga, New Zealand.

Baueri. This is a tree from ten to twenty feet in height, with trunks from four to six inches in diameter, rather widely spaced beneath the canopy of closely interlacing branches and twigs. I estimated the usual space between tree trunks at three meters. The longer trunks tend to be prostrate or slanting, growing toward the prevailing wind, which places the leaf canopy quite uniformly eight or ten feet above the ground. The rather thick oval leaves are set on coarse twigs, which are noticeably brittle. The scanty additional elements in this vegetation are listed by Sladden. To the west there is a somewhat less steep slope, and a separate, though low, rocky eminence at the end of the island. On this slope the large-leaved fern, *Asplenium lucidum*, forms a considerable stand, almost an understory, but with no reduction in number of the petrel burrows described below. Toward the main peak of the island, where the slope is steepest, there are clumps of *Asplenium flaccidum*, the cut-leaved fern, said to have a different habit of growth on the island than on the mainland. Sladden's list of the known plants amounts to only some 22 species of flowering plants and three of ferns.

Perhaps the most characteristic experience of a visitor to the coprosma forest is to step down to mid-shin depth, or even to his knee, into a shearwater burrow. Beneath the coprosma canopy the surface of the reddish brown soil is bare, with an occasional clump of *Asplenium*, and there is scarcely any other vegetation except at the rocky pinnacle that crowns the island. The large openings of the mutton bird nest burrows (four or five inches in diameter) are everywhere. They are a half-meter to a meter apart, sometimes side by side when they are juxtaposed to a tree-root. The openings are beside or beneath a rock, or at the base of a tree, or quite in the open. Many of the openings are filled with trash, leaves, twigs, and feathers that are swept along by the steady and strong westerly wind over the bare soil surface. Beneath the surface it seems as if there must be more burrow than space between burrows. When one steps close to a tree, thinking to avoid breaking through, one is as likely to break through as not. Two burrows per square meter is a conservative estimate of their spacing, which yields an estimate of 70,000 for the total number of burrows. The number inhabited must be much fewer. Two brooding birds were uncovered, and one egg, broken by my foot, contained a young bird almost ready to hatch. The egg is about the size of an ordinary hen's egg, but slightly elongate. An unwary hand, reaching for an egg, may receive a sharp peck from the brooding parent that has retreated into the burrow when it was broken open.

The source of the leaf trash and ultimately of the soil was not understood until I had passed the night. Precisely at eight o'clock, shortly after sunset, the mates of the brooding birds begin to arrive from the sea. With outspread wings they "crash-land" on the coprosma leaf canopy and then drop vertically to the ground with a thud, amid a shower of leaves and twigs. Each bird then scurries

FIG. 29. Karewa Island from southeast. Photograph by Percy F. Carter.

about on the ground in search of its proper burrow. A few powerful scratches clear the opening of the dirt and leaves that have fallen in during the day; my bed was repeatedly showered during the early evening. I counted eight birds that came in to the area immediately around my sleeping bag, in a space estimated at 4 by 8 meters. One dropped so close to my head that its wings brushed my face as it dashed off. By a quarter past eight more and more birds were arriving on the island, and a most remarkable conversation and chorus began among them.

This chorus is one of the most astonishing nocturnal phenomena in all my naturalist's experience of nocturnal voices. Every term applied to vocal sounds is appropriate to some part of it. It begins as soft mutterings and cluckings, apparently of greeting between the underground brood partners and their incoming mates. When the birds have arrived in full numbers, the variety and volume of sound increases. Individual voices are raised in loud crowing and cackling, mewing and caterwauling, cooing and clucking, squeaking and cry-

ing, yelling and wailing. Some of these sounds come from above ground and some are muffled within the subterranean burrows, with corresponding and extraordinary modifications of their tone and volume. Some of the pleading sounds might be from young birds asking to be fed; but I found no young, and certainly most of this great volume of sound is produced by the adult birds. It does not seem to be a courtship phenomenon, for the nesting cycle was well advanced. I take it to be a normal part of the family life of the mutton bird. The chorus rises, with a medley of all the sounds, in a tremendous crescendo to a fortissimo in which every bird on the island seems to be involved, and one can feel the air vibrating in one's lungs. Then the sound dies away until there is only cooing and muttering, only to build up again to the fortissimo. Promptly at dawn, at 4 o'clock, the sounds come to an end, and most of the birds have soon left the island. It seems a plausible hypothesis that the birds alternate in brooding and that sleeping is accomplished during the day, either at sea or on the nest. There is not a sound from the shearwaters on the island during the day. The second night repeated the cycle of arrival at dusk, an eight-hour-long chorus, and departure at dawn.

The extremely clumsy mode of landing in the branches of the coprosma leads to an occasional tragedy. I saw a freshly dead mutton bird hanging by its head, its neck wedged in a narrowed fork of two branches. Mr. Sladden reports seeing the same kind of accident.

The soil must have begun with rock-decay, which seems to have penetrated deeply into some exposed rock surfaces. On some areas no boulders at all remain at the surface, but elsewhere the reddish brown soil extends from rock to rock. As soon as there was enough soil for the shearwaters, the vegetation drawn into the burrows must have contributed rapidly to soil formation. One may imagine that the first successional stage might be a bunch grass cover. Then, when the coprosma forest developed, with its accompanying mutton-bird burrows, the stage was set for the rapid development of a peculiar humus-rich soil, somewhat paradoxically, since no leaf mulch gathers on the surface. The crash landings of the birds produce showers of green leaves and twigs. These are swept by the wind or merely slide by gravity along the almost polished soil surface into the openings of the nest burrows. There most of this trash must be trodden inward into unused parts of the burrows. Then, together with dead nestlings, infertile eggs, eggshells, feathers, remains of food, and the droppings of the birds, and with the excreta and remains of the

tuataras that also inhabit the burrows, all this material decays to form a subterranean humus, and with the repeated burrowing operations of the birds, the whole is mixed to uniformity to a depth of some two feet, with no trace of soil profile.

Against all this introduction to the environment in which the tuatara lives, my actual experience with the reptile I had come to see makes an anticlimax. The first tuatara appeared at about a quarter past eight, when the light was already failing. As I went back to my bed to get my flashlight, another tuatara ran in front of me and wedged itself between canvas and sleeping bag, a kind of poetic compensation for my failure, through years of sleeping out in the western United States, to find a rattlesnake in my blankets. A second tuatara was captured some ten meters away, when it retreated into a hole as my light shone on it. In extracting it, in spite of pulling carefully, I broke the tail near the tip. No further specimens were seen.

On examination, the following morning, the larger specimen (432 mm. in total length) was seen to be dull gray, with the skin shedding in patches. Where freshly pulled away the skin was much lighter gray and closely set with still lighter small spots; the throat was darker gray, greenish on the folds of skin. By far the most unlizardlike feature was the winking of the eye by the slow-moving third eyelid, the nictitating membrane, a device that appears to function so well to moisten and clean the eyeball that one could lament its loss in the higher vertebrates. The smaller specimen (362 mm.) was much brighter brown, the belly yellowish brown, and the skin under freshly shed patches was green with lighter yellowish-green spots and vermiculation. This specimen had brown longitudinal streaks under the chin and yellowish-green vermiculation on the top and sides of the head. The claws were brown, reddish at the tip. The spines of the crest along neck and back were pale yellow. The eye of the larger specimen was dark brown, almost black, whereas that of the smaller one was much lighter brown. I could discern no certain sex difference, though the more massive head of the larger specimen might well indicate that it was a male. One of the specimens urinated profusely at 9 o'clock A.M., and one bit my hand through the sack and hung on for a matter of minutes, just failing to break the skin.

Mr. Sladden reports that for some years he had seen only uniformly large specimens of the tuatara, and he fears that the Karewa colony may be dying out. My three-quarter-grown specimen offers a mite of testimony against this conclusion. Taking into considera-

tion the numbers of burrows of the shearwaters, and in spite of the few specimens seen, I feel certain that there must be some hundreds, at least, of tuataras now on the island.

All my search on the following day did not disclose a glimpse of a tuatara abroad, and on the second evening I found no specimens; it must be confessed that by that evening I had become so exhausted by the succession of stepping through into mutton-bird burrows and raising myself out again that I could scarcely move.

I found two tuatara tail-tracks leading into burrows, and four scats were collected, one very fresh. The scats are curiously like those of carnivorous mammals, all about two inches long and one-half inch in diameter (51 by 11 mm. to 55 by 15 mm.), with conspicuous beetle shards to be seen on their outer surface. My colleague Henry Dybas (Associate Curator of Insects in Chicago Natural History Museum) supplies the following analysis of three scats (one was apparently lost).

No. 1, Karewa Island, January 27, 1949: Composed of dirt particles and organic remains, which included plant fibers, eggshell fragments, down feathers, and fragmented insect remains.

The insect fragments composed more than 25 per cent of the bulk of the scat and consisted chiefly of beetle fragments. Predominant among these were a single species of Tenebrionidae about 17 mm. long, a species of Elateridae about 15 mm. long, a species of Scarabaeidae 12 mm. long, and two types of Curculionidae more than 10 mm. long. About thirty heads of beetles of these four families were recovered, but probably two or three times that number of specimens had been eaten. Other beetle families were represented by single specimens of the Histeridae and Staphylinidae.

Other groups of insects included were Formicidae (ants), Homoptera, and calyptrate Diptera. Numerous other insect fragments were not identified.

No. 2, Karewa Island, January 28, 1949: Composed of dirt and rock particles, plant fibers (including rootlets, seeds, and moss fragments), down feathers, and insect fragments.

The same four beetle families as in scat No. 1 predominated. In addition, one beetle larva (Tenebrionidae?) of about 30 mm. and one large spider of about 25 mm. were found.

No. 3, Karewa Island, January 28, 1949: Entirely composed of bird bones and feathers except for a few plant fibers and insect remains (Tenebrionidae, etc.).

A

B

FIG. 30. A, Bare ground beneath coprosma canopy on Karewa Island. B, Karewa Island tuatara, showing spotted pattern of specimen shortly after shedding its skin. Both figures from motion picture film, courtesy of Robert Cushman Murphy.

The bird remains found suggest a somewhat more than casual predation on nestling birds by the tuatara. The bird bones from scat No. 3 included the bill of a young bird, together with sprouting feathers. These were submitted to Mr. E. G. Turbott, who took the trouble to macerate the skull of a diving petrel (*Pelecanoides urinatrix*) to confirm his first supposition that the remains represented a fledgling bird of that species, and an individual about six weeks of age. The occurrence of the diving petrel on Karewa is not entirely surprising, for Falla (1934) indicates that this much smaller species may occur there, nesting within the burrows of the larger shearwater, *Puffinus carneipes;* my record for January 28 is much later than any that were known to Falla. Mr. Turbott writes, however, that young diving petrels were found in their burrows as late as January on the Three Kings Islands. The capture of a fledgling of the small diving petrel by the tuatara is evidently much more likely than would be that of a juvenile shearwater.

The insect and spider life observable on Karewa by day did not suggest an adequate food supply for the tuatara. The only types observed were non-anopheline mosquitoes, houseflies, and a few other Diptera; an abundant and noisy cicada sounding very much like a grasshopper; a few beetles; and a very few spiders.

The land birds were fairly abundant, of two or three species, singing in a very pleasing chorus after the mutton birds fell silent at dawn. These birds were seen to be feeding on the abundant yellow berries of the coprosma.

After failing to find the way on the first attempt, a hint from Mr. Carter put me on the right track,[1] and I climbed to the peak of the island. From the coprosma thicket rises a pinnacle composed of a dozen rocks, some six feet high, with two small flat spaces, each about a meter square, littered with stones from 10 to 20 centimeters in diameter. As one emerges into the sun at the peak the most striking vegetational feature is a tangled mat of several square meters of pohuehue, *Muelenbeckia,* surrounding the large boulders, with *Pseudopanax lessonii* between the rocks, and the thicket of *Muelenbeckia* re-enforced with the thick-leaved salt plant, *Mesembryanthemum,* on the ground.

Beneath the smaller rocks and under the mats of *Muelenbeckia* two species of lizards occurred in some abundance. The viviparous gecko *Hoplodactylus* was represented by 24 or 25 specimens seen, of

[1] Mr. Carter sailed out on the 27th to make certain that I was properly supplied for my second night, and called for me on the 28th.

which three or four were quite small. Six specimens of a small dark-colored skink of the genus *Emoia* were seen. The skinks skittered quickly downward and out of reach on the steep seaward face of the pinnacle. This sharply limited lizard colony may well extend downward on the steep outer slope, where no soil accumulates and coprosma does not grow. Two isolated pinnacles of rock with a few bushes at their summits stand as outliers of the peak of the island, and these are continued seaward by a few low rocks that rise above the level of high tide.

Mr. Bernard Sladden, the well-known New Zealand naturalist, came up to the *Raumatu* in his launch on our return journey on the 28th, and I owe to him the names of the plants for my description of the tuatara environment.

This environment, remarkable for its peculiar soil and for the association of shearwater and tuatara, appears to represent a climax condition produced by the interaction of animals and vegetation. The striking conditions of soft soil and coprosma thicket appear to have been present on the now very different Stephen Island, before sheep were brought in (Thilenius, 1899; cf. Schmidt, 1952). The whole life history of the tuatara is now being examined in critical detail by William Dawbin, my companion on a later visit to Stephen and Trios Islands.

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