

THE EFFECT OF GOATS ON VEGETATION OF THE KERMADEC ISLANDS

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Goats were present on Raoul, the largest island of the Kermadecs, in 1836, (Rhodes *in* Straubel 1954) although Wright and Metson (1959) stated that they were liberated there in 1842. Rhodes said that they were few in number on Raoul whereas he stated that in 1836, the second largest island in the group, Macauley, "abounds with goats". This implies that these animals must have already been present for a number of years. On Macauley the vegetation was burnt to some degree prior to the arrival of the goats. As a result, it has grassland covering most of its surface whereas Raoul is still forested.

In July and August 1966, an expedition organised by the N.Z. Wildlife Service probably exterminated the goats on Macauley (Williams and Rudge 1969). As a result of studying the vegetation at the same time, I am convinced that several of the endemic species were then no longer growing there. The only areas inaccessible to goats were the steep cliffs around the coast and some of the larger gully sides. Such habitats were often very unstable because of the soft tuff deposits of which the island is mainly formed; consequently the vegetation was generally rather sparse. The most prominent plants were *Cyperus ustulatus* A. Rich., *Disphyma australe* (Sol.) J. M. Black, *Lobelia anceps* L.f., *Polypogon monspeliensis* Desf., and *Scirpus nodosus* Rottb. The few woody plants were almost entirely confined to the harder volcanic rocks of the cliffs on the western side. The grassy surface of the plateau was dominated by rice grass, *Microlaena stipoides* R.Br. in 1966 (not *Polypogon monspeliensis* as stated by Cheeseman (1888) and Oliver (1910) as a result of their very brief visits) and this often covered considerable areas to the virtual exclusion of any other plant. Where this grass was less dense the introduced annual grass *Vulpia bromoides* (L.) S. F. Gray was usually abundant and, on the crests of the shallow ridges running across the plateau, *Notodanthonia racemosa* (R.Br.) Zotov had formed flat mats. Repeated grazing must have been

partly responsible for the development of this habit. Browsing had also resulted in the introduced sedge *Cyperus brevifolius* (Rottb.) Hassk. forming short dense mats towards the bottom of the shallow gullies; this appearance being quite unlike that usually found in this species elsewhere. On Raoul the two last-named plants do not form short turf. The overall appearance of the plateau as early as 1887 must have resembled that seen in 1966 because Cheeseman (1888) found "... a beautiful sward of natural grass".

The above monocotyledonous herbs provided the main source of food for the large goat population, and, apart from limited areas, dicotyledonous herbs were relatively insignificant there during the winter of 1966. Thus, it is of interest to compare the brief outline of the vegetation just given with statements made at the time of the discovery of Macauley in 1788 by Captain W. Sever and the crew of the "Lady Penrhyn". The island had little grass on it then, judging from Arthur Bowes' comments on the event in his unpublished journal. Furthermore, Captain Sever noted that the plateau was covered by "a coarse kind of grass" and "great plenty of the wild mangrove" (Oliver 1910). The "mangrove" must have been the Kermadec ngaio, *Myoporum obscurum* Endl.* and the "grass", *Cyperus ustulatus*. The relationship of goats to the former is considered below. In addition to the frequency, in 1966, of the latter on the tuff faces around Macauley as already mentioned, it formed the dominant vegetation of the cap of the adjacent Hazienda Islet where there have apparently never been any grazing animals. However, there was no sign of the saw-edge leaves of this sedge on top of the plateau in the winter of 1966.

From early November 1966 to late January 1967, I made a botanical survey on Raoul and the adjacent Herald Islets as a member of the 1966-67

* This is a redetermination of the Kermadec ngaio and the reasons for it are discussed by Sykes (in press).

Ornithological Society of New Zealand's Expedition to the Kermadecs. It now seems clear that some of the endemic species are to be found only on Raoul itself and at least one of them, *Hebe breviracemosa* Ckne & Allan, seemed to be already extinct. This was apparently once fairly plentiful but was noted by Oliver (1910) as being rare and very palatable to goats. Several of the others are now uncommon, especially *Homalanthus polyandrus* (Muell.-Arg.) Cheesem., *Boehmeria dealbata* Cheesem. and *Pseudopanax kermadecense* (W. R. B. Oliver) Philipson, and this is certainly because of the activity of the goats. Mature trees set quantities of fruits and viable seeds but regeneration was largely inhibited because the seedlings were eaten before they could grow tall enough to be out of their reach. *Boehmeria dealbata* and *Homalanthus polyandrus* have been recorded from Macauley but neither grows there now.

The forests of Raoul are mainly dominated by the Kermadec pohutukawa, *Metrosideros kermadecensis* W. R. B. Oliver. This species is favoured by goats and, in most areas, few or no young plants were seen. Since this is the main canopy tree, its eventual disappearance over large parts of the island will obviously result in drastic changes to the rest of the vegetation as well. That such modifications are likely is shown by Atkinson's (1960) report on the effect that browsing goats had had upon the vegetation of Cuvier Island near the New Zealand coast. The original forest there was dominated by the New Zealand pohutukawa, *Metrosideros excelsa* Gaertn. but regeneration of this and other tree species had been completely stopped and, on the seaward slopes especially, there was little woody vegetation left. The Raoul forests are noted for their large tree ferns belonging to two endemic species of *Cyathea*. These are becoming less common now since regeneration is virtually absent, apart from a few plants which begin life as epiphytes. In certain areas there are no living tree ferns but old dead trunks are still very common. Since spores are normally found in vast quantities it seems that their failure to produce mature plants in such places must be ascribed to goats. In other areas, such as around the small Tui Lake, which lies in a rather remote part of the crater, the living tree ferns are obviously much less common than formerly, judging from photographs taken earlier this century. That neither of the two filmy ferns in the genus *Trichomanes* collected by Dr W. R. B. Oliver in 1908 were seen during the 1966-67

Expedition must stem, at least in part, from the decrease of the leaning *Cyathea* trunks which formed their main habitat. Even the epiphytes themselves were not safe from direct attack because goats were frequently seen climbing the leaning trunks of the Kermadec pohutukawa and mahoe, *Meliccytus ramiflorus* J. R. & G. Forst., and accessible vegetation was browsed to 10 metres or more above the ground. Epiphytic ferns, particularly *Asplenium* species, were often eaten, as were the young shoots of the Kermadec pohutukawa and mahoe themselves.

The narrow coastal strips behind the beaches are a favourite habitat for goats; and Atkinson (1964) believed that on Cuvier Island they were attracted to such coastal habitats by the salt on the vegetation. Although I did not confirm this for the Kermadecs, there is little doubt that the accessible coastal areas of Raoul support a sparser or a more adventive-dominated flora than formerly. An indirect effect of browsing by goats is that the frequent old landslips around the coasts of Raoul and Macauley have been kept more open and are consequently more unstable than they otherwise would be. Palatable species such as the karo, *Pittosporum crassifolium* A. Cunn. and the endemic Kermadec taupata, *Coprosma petiolata* Hook. f., are now mainly confined to more or less vertical cliff faces, and the former is very rare even there. On Macauley in 1966 only a single clump of this taupata was seen near the base of the precipitous western cliffs. Even the Kermadec ngaio, which often forms a characteristic coastal scrub, has been greatly reduced in many parts of Raoul. On Macauley, this once abundant and presumably often dominant species was found on only a few nearly vertical cliff faces in 1966. Davison (1938) considered that it was only a question of time before this ngaio on Raoul would also be confined to cliff faces inaccessible to goats. The often abundant ice plant, *Disphyma australe* was also browsed to some extent on the Raoul coasts.

A habitat of special botanical interest on Raoul Island is the crater floor which was the site of an eruption on 21 November 1964. The details of recolonisation of the devastated and partly devastated areas would make an important scientific study. Unfortunately, this is also an area of great activity for goats. Even the, as yet, very sparse flora of the Green Lake crater bed near the centre of the eruption was being strongly browsed by late 1966.

Among the plants eaten was the Kermadec tree tutu, *Coriaria arborea* var. *kermadecensis* W. R. B. Oliver which must be poisonous to many other animals. Erosion was already affecting this region strongly and the non-regeneration of the Kermadec pohutukawa, particularly, will thus markedly modify the future topography of the central part of the crater. Movement of goats across the open parts of the crater floor followed a fairly regular diurnal pattern in the summer of 1966-67.

Other indigenous species were seen to be eaten to a greater or lesser degree. The endemic Kermadec nikau, *Rhopalostylis cheesemani* Cheesem., fruits prolifically and the seeds germinate freely, but sometimes there were very few young plants, although generally this was still a common palm on Raoul. In other parts, particularly in an area of wet forest around Mount Junction (Prospect) on the crater rim, there was a dense short carpet of small seedlings beneath the tall parent trees in the summer of 1966-67. No larger seedlings were seen, presumably because goats had checked any further growth. The same phenomenon was noted in connection with this species by Davison (1938). The endemic *Coprosma acutifolia* Hook. f. was said by Oliver (1910) to be one of the principal understorey plants in the dry forest and to often form the canopy in the wet forest. At present it is relatively uncommon and the numerous seedlings which spring up near the prolifically fruiting female trees are soon killed by goats.

The wharangi, *Melicope ternata* J. R. & G. Forst., was not as uncommon as the previous species but, because of the activity of these animals, it can by no means be described as plentiful today, as it was said to be by Cheeseman at the time of his visit in 1887. Similarly, karaka, *Corynocarpus laevigatus* J. R. & G. Forst., may have decreased considerably because of browsing killing the young plants. There appeared to be only one tree of the parapara, *Heimerliodendron brunonianum* (Endl.) Skotts. growing on Raoul during the summer of 1966-67, this rarity again being mainly attributable to goats. Oliver (1910) remarked that they barked the parapara trees and Davison (1938) noted that they had nearly caused the extinction of the species there. The effect of goats on some of the indigenous terrestrial herbaceous species was less obvious or impossible to determine but browsing may have been responsible for the rarity of some of them. However, half-eaten fronds of the two *Blechnum* species were a common sight on Raoul.

An indirect effect of browsing has been to cause changes in the vegetation because of the unpalatability of the two main understorey trees on Raoul (sometimes they are canopy species also). Thus *Myrsine kermadecensis* Cheesem. and *Ascarina lucida* var. *lanceolata* (Hook. f.) Allan were probably commoner in 1967 than previously and often formed dense and almost pure stands in the dry and wet forest respectively. The unpalatability of such ferns as *Pteris comans* Forst. f. seems to be partly the reason why they were also so common. And this seems to be the reason why such a species as the introduced terrestrial aroid, *Alocasia macrorrhiza* (L.) Schott. has been able to increase so markedly that it now often dominates large areas in the forest. The dense stands of this large-leaved plant which nearly exclude light from the forest floor means that regeneration of indigenous woody species in these places is further inhibited.

In conclusion, the present time is probably a critical one for the indigenous plants of Raoul, the only Kermadec island with much more than what may be termed a purely coastal type of flora. If the goats could be eliminated soon, the rarer species would be saved and the characteristic composition and appearance of the forests would be largely maintained. Further evidence that this would be so is clearly afforded by the fact that several of the rarest endemic species are now mainly found in the region of the Meteorological Station on the Terraces of the northern side of Raoul. Examples are *Boehmeria dealbata*, *Coprosma acutifolia* and *Homalanthus polyandrus*. The reason can only be that the pressure of goats on the vegetation is less there because of intensive local shooting by the staff. If the goats remain the flora will change, probably at an accelerating rate, and introduced species will take control over increasingly large areas. In addition to the *Alocasia* mentioned above, a number of other introduced species are much in evidence now and are continually increasing at the expense of the indigenous vegetation, partly because of their unpalatability.

Some of the observations noted here were considered by the late Dr W. R. B. Oliver, for many years Director of the Dominion Museum, Wellington. Thus, in a memorandum dated June 10th 1937, to the Under-Secretary, Lands and Survey Department, he recommended the extermination of the goats on Raoul Island. Estimates of the number now present vary, but in my opinion there

are probably not more than were found to be on Macauley Island, namely about 3,200 (Williams and Rudge 1969).

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