HABITAT FACTORS AFFECTING SADDLEBACKS ON HEN ISLAND

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The North Island saddleback *(Philesturnus carunculatus rufusater)* was formerly widespread on the mainland and appears to have almost died out by 1875 (Buller 1888). It is now common only on Hen Island. A study was begun in 1963 by members of the Wildlife Branch, Department of Internal Affairs, the Ornithological Society of New Zealand and the Department of Scientific and Industrial Research, to help determine the factors influencing its numbers and survival on Hen Island. This paper is a preliminary report on habitat based on observations made during August 1963, January 1964 and May 1965.

Hen Island lies 12 miles south-east of Whangarei Heads, is 1195 acres in area, and rises to a height of 1,400 ft. It is a much dissected andesite volcano with very steep slopes, several huge cliffs, and many rocky outcrops.

FOODS AND FEEDING BEHAVIOUR

The greater part of the diet consists of non-flying invertebrates. The diet includes larvae, pupae, adult beetles, moths, wetas, spiders, centipedes, succulent fruits, nectar, flower buds and apical buds. Large wetas up to 2 in. in length are readily eaten but the lower size limit of food taken is not known. There have been a number of records of feeding on fruit, particularly those of fivefinger *(Pseudopanax arboreum)* though few fruit are taken at a time (Table 1). Trees that produce large amounts of nectar on Hen Island are puriri *(Vitex lucens)*, kohekohe *(Dysoxylum spectabile)*, flax *(Phormium tenax)* and kowhai *(Sophora microphylla)*. In May, birds were seen feeding from puriri flowers. Reischek (1887) saw birds feeding from flax flowers. Kohekohe, abundant in many parts of the island, was in full flower during May but flowers apparently were not visited by saddlebacks. Whether nectar is ever an important part of the diet is not clear but saddlebacks in captivity drank honey water frequently (Merton 1966a).

TABLE 1. *Feeding stations of the saddleback on Hen Island.*

Feeding Stations	No. of observations	% of total
Branches, limbs, twigs	157	29
Foliage	119	22
Ground	95	18
Dead branches and limbs, fissures and holes	46	9
Trunks	36	7
Fruit	33	6
Dead foliage	28	5
Flowers	10	2
Buds	8	1
Aerial feeding	3	< 1
Totals	535	100

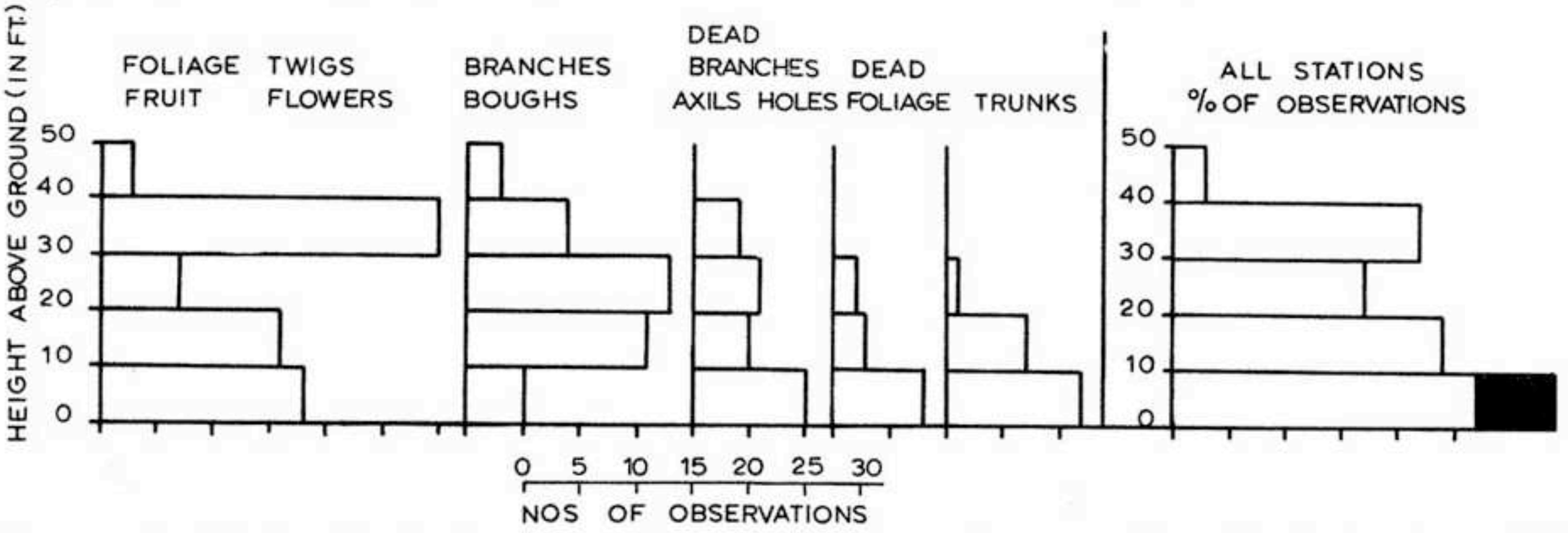

FIGURE 1. *Height distribution of saddleback feeding stations on Hen Island based on 199 observations made during August and May. Note that forest height on Hen Island rarely exceeds 40 to 50 feet. (Shaded portion represents ground feeding.)*

The analysis of feeding records (Table 1, Fig. 1), modelled on a study by Gibb (1961), shows that saddlebacks feed from a wide range of stations distributed through all heights in the forest. The original data (Atkinson 1964, 1966; Merton 1966b) indicated seasonal trends in the use of some feeding stations but more sampling is necessary for confirmation. The most frequently observed method of feeding is that of probing and levering under bark and in holes and fissures of living and dead wood. Timed observations, however, indicate that sometimes saddlebacks spend more than a third of their feeding time on the ground using mainly the bill for tossing aside leaves or probing. Most of the day is apparently spent in continuously searching for food but this impression could be wrong if birds remain concealed when resting. Further information is needed about foods and feeding behaviour, particularly during the breeding season. The gathering of this information would be aided by colour-banding pairs of birds so that the whole pattern of daily activity could be followed.

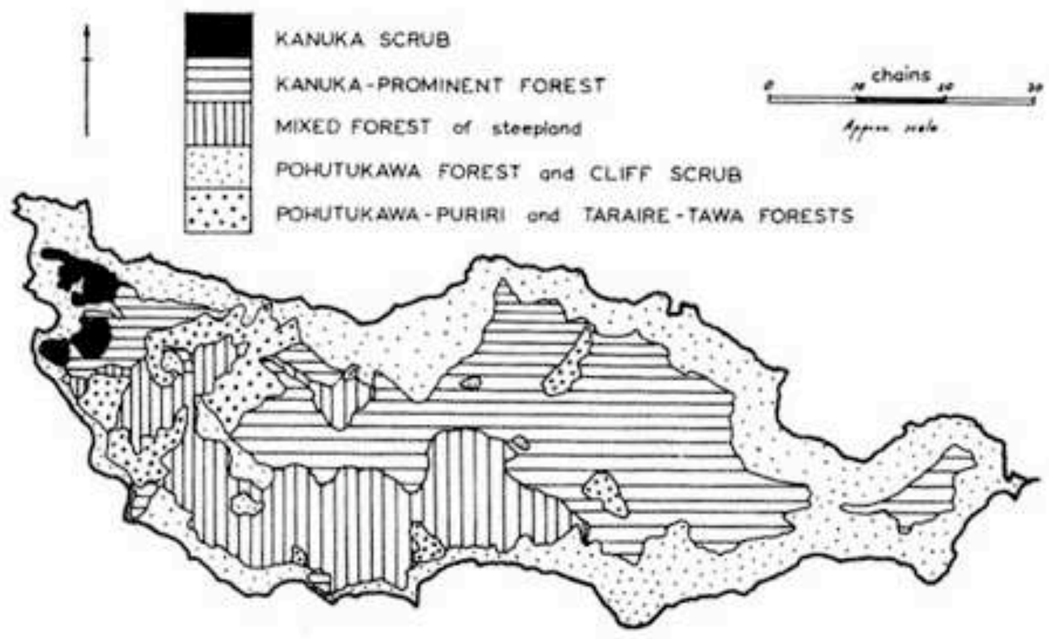

FIGURE 2. *Simplified vegetation map of Hen Island. Based on unpublished map by one of the writers (I.A.E.A.).*

DISTRIBUTION OF SADDLEBACKS IN RELATION TO VEGETATION

The vegetation of Hen Island may be classified into five types (Fig. 2):—

1. Kanuka *(Leptospermum ericoides)* scrub (6-20 ft. high) associated with shallow stony soils on the western slopes. The undergrowth here is sparse.
2. Kanuka-prominent forest (25-35 ft. high) associated with heavy clays of the upper slopes and main ridge. Small stands also occur on headlands along the southern shoreline. This forest has a dense understorey and the kanuka is in various stages of replacement by tawa *(Beilschmiedia tawa)*, puriri, cabbage tree *(Cordyline australis)* and other species.
3. Mixed forest (10-35 ft. high) associated with stony skeletal soils of the steep and very steep slopes. This forest is dominated by immature trees of puriri, taraire *(Beilschmiedia tarairi)*, tawa, mahoe *(Melicytus ramiflorus)*, hohere *(Hoheria populnea)*, kowhai and five-finger. The understorey is dense.
4. Coastal pohutukawa *(Metrosideros excelsa)* forest (20-40 ft. high) and coastal scrub associated with very friable clay loams (often burrowed by petrels) and stony soils of the cliffs. There are a number of rapidly growing species present: karaka *(Corynocarpus laevigata)*, kohekohe, mahoe, whau *(Entelea arborescens)*, kawakawa *(Macropiper excelsum)* and coprosmas, all of which contribute to a dense understorey.
5. Pohutukawa-puriri and taraire-tawa forests (30-50 ft. high) associated with clay loams of the easy and moderately steep lower slopes. These are mature forests in which large diameter trees (> 12 in. d.b.h.) of pohutukawa and puriri are being replaced by taraire and tawa. The understorey is generally sparse.

Saddlebacks have not yet been observed in the kanuka scrub which covers about 25 acres. An unpublished census carried out in May 1965 by A. M. C. Davis and J. L. Kendrick indicates a lower density of saddlebacks in this western part of the island where this scrub occurs (A. M. C. Davis, pers. comm.).

Saddlebacks are common throughout the remainder of the island with the exception of the mature pohutukawa-puriri and taraire-tawa forests (approximately 80 acres). Four sets of observations suggest that these types are not used by saddlebacks to the same extent as are other forests:—

(i) Observers making traverses through an extensive stand of taraire-tawa forest on the south-western slopes often failed to record any saddlebacks.

(ii) One of the writers (D.J.C.) spent some 48 hours over a total period of 8 days (January and May) in a stand of forest transitional between the mature forests mentioned above and coastal pohutukawa forest. Saddlebacks were frequently seen and heard in the latter but not at all in the former.

(iii) The type of forest was also noted in some of the feeding observations (Table 2). The greatest number of times that birds were seen feeding was in kanuka and pohutukawa coastal forest even though a comparable time was spent by observers in pohutukawa-puriri and taraire-tawa forests.

TABLE 2. *Saddleback feeding in relation to forest types on Hen Island.*

Forest type	No. of times when birds were seen feeding
Kanuka-prominent forest	42
Mixed forest of steepland	14
Coastal pohutukawa forest	32
Pohutukawa-puriri and taraire-tawa forests	9
Total	97

(iv) During the transfer of saddlebacks from Hen Island to Middle Chicken Island in January 1964, most of the birds were captured in the zone of forest within 200 ft. altitude of the shoreline (Merton 1966a). This partly reflects accessibility; nevertheless, birds were usually difficult to find in the pohutukawa-puriri and taraire-tawa forests at higher levels. By May 1965 saddlebacks had reoccupied the coastal zone but were scarce in the taraire-tawa and pohutukawa-puriri forests.

Thus, as a hypothesis, it is suggested that on Hen Island saddlebacks obtain most of their food from the secondary and coastal forests in which there is a dense understorey and where the turn-over of plants is rapid. Saddlebacks are apparently not wide-ranging birds and an investigation of their territories in relation to type of vegetation would be profitable.

FACTORS AFFECTING THE DISTRIBUTION OF SADDLEBACKS ON HEN ISLAND

Three environmental factors that may influence the distribution of saddlebacks require detailed investigation:—

1. *Production of dead wood.* Because of site instability, replacement of trees by thickets of young plants is frequent in the mixed secondary forest of the steep slopes. Near the shore there is continual replacement of many trees, except pohutukawa, because of damage to crowns by wind-carried salt. A relatively high production of dead wood may be expected from these forests. This in turn may result in large numbers of invertebrates in this wood.

2. *Nature of the litter.* During May 1965 litter was examined for invertebrates. A rake 18 in. wide (2 in. nails spaced 1 in. apart) was used to uncover the mineral surface quickly over an 18 x 18 in. quadrat. All invertebrates seen were noted and amphipods assessed according to five abundance classes (Table 3). It is not known whether saddlebacks eat amphipods. However, even with this method of crude sampling, large differences are apparent in the numbers of amphipods found in different litter types. Observations of the nature of taraire litter suggest that it may be inferior as a source of food for saddlebacks.

TABLE 3. *Abundance of amphipods in three types of litter on Hen Island.*

No. of amphipods seen per quadrat	Percentages of samples in each abundance class		
	Taraire litter (50 samples)	Puriri litter (40 samples)	Coastal forest* (50 samples)
>10	0	43	10
6–10	4	38	22
2– 5	22	13	30
1	20	2	18
None observed	54	4	20

3. *Water.* The extent to which saddlebacks need water is unknown. They have been observed drinking on at least 13 occasions both from water-holes and from droplets of rain caught on fruit and leaves. It is possible, as discussed by Blackburn (1964), that, during droughts, water is obtained from the expanded leaf bases of collospermums *(Collospermum hastatum)* which are widespread on the island both as epiphytes and on rocks. On some other islands this plant is uncommon or absent. Dr. J. A. Gibb (pers. comm.) has pointed out that if saddlebacks eat mostly invertebrates (60% water) and fruit (> 60% water) they may not often need water from other sources.

* Litter from pohutukawa, karaka, *Meryta sinclairii*, mahoe, kawakawa and *Coprosma macrocarpa*.

FACTORS AFFECTING THE NUMBERS OF SADDLEBACKS ON HEN ISLAND

1. *Reproductive biology*. Clutch size is given by Oliver (1955) as two and brood sizes of from 1 to 3 have been recorded (Blackburn 1964). In January 1964 about 8 different family parties were observed, all with broods of one (D. V. Merton, pers. comm.). Studies of nesting success and of population turn-over are needed, again requiring colour-banded birds.

2. *Predation*. This is an open question. Stead (1937) suspected that kiore *(Rattus exulans)* might occasionally destroy nests but direct evidence is lacking*. Predation of nestlings by moreporks and use of saddlebacks as hosts by shining cuckoos need to be investigated.

3. *Competition for food*. On Hen Island the animals most likely to compete with saddlebacks for food are bellbirds, tuis, white-eyes, blackbirds, moreporks and kiore. Feeding observations of bellbirds, tuis and white-eyes in May suggest that the greatest overlap with saddlebacks at this time is in searching for insects in the upper foliage. Bellbirds and tuis are abundant on the island but it is not known whether they take the same food from foliage as saddlebacks.

Kiore are widespread and abundant. An unpublished investigation by one of the writers (D.J.C.) has shown that kiore take a wide range of invertebrates. A similar wide range of invertebrates is readily eaten by captive saddlebacks. As well as feeding on the ground, kiore also feed in the tree branches and crown, and so may compete in both places with saddlebacks. Blackbirds and hedge sparrows take ground insects and fruit but are not common on Hen Island.

The food of moreporks includes spiders, beetles, moths, wetas and cockroaches (Lindsay and Ordish, 1964). Saddlebacks take these animals during the day and should these same animals emerge at night they are vulnerable to both moreporks and kiore. Moreporks are numerous on Hen Island perhaps, as suggested by Stead (1937), because kiore are an abundant food. These food relationships are summarised in Fig. 3 which, though it represents only part of a vastly more complex food web, may nevertheless be a useful focus for future studies.

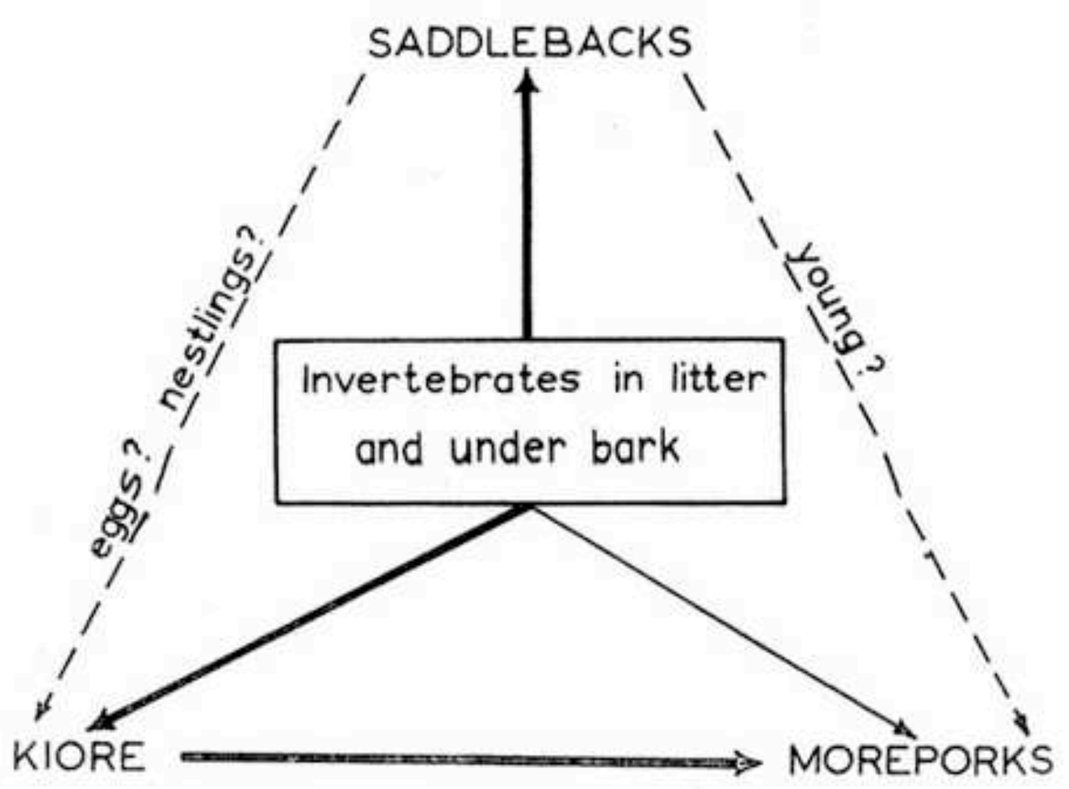

FIGURE 3. *Possible relationships between saddlebacks, kiore* (Rattus exulans), *morepork and a common food source on Hen Island. Arrows indicate flow of energy as food.*

Kaka range widely over the island and take food from under bark but their activity in any one area seems small compared with that of saddlebacks.

To summarise, saddlebacks appear suited to exploit one source of food more effectively than any other New Zealand animal. This source is the population of wood-inhabiting invertebrates that live under bark or in holes and fissures and that do not emerge at night to become potential food for kiore or moreporks.

DISCUSSION

Saddlebacks were abundant in the North Island until at least the 1850's after which their numbers apparently declined rapidly in less than 20 years to virtual extinction (Buller 1888). Except for those places where the habitat was completely destroyed, disease, predators and food supply have been invoked as possible factors leading to this decline.

If disease had decimated mainland populations of saddlebacks, we would not expect the Hen Island population to be any less susceptible since it is known that populations on small islands tend to become genetically uniform (Mayr 1942). Starlings, blackbirds, thrushes, hedge sparrows, chaffinches, house sparrows and white-eyes have reached Hen Island (Skegg 1964) and saddlebacks may have been exposed to diseases borne by these birds.

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* Other potential mammalian predators (see below) are not present on Hen Island. (Ed.)

Considering predators, mustelids were not introduced to the North Island until the 1880's (Wodzicki 1950), *after* the main decline of the saddleback had taken place. Turbott (1947) suggested that cats exterminated saddlebacks from Little Barrier Island and this may also be true of Cuvier Island where cats were introduced by lighthouse keepers in the 1880's. In this instance goats may also have contributed to their decline by destruction of the understorey and litter layers. There may be more cats on these islands than on the mainland because of the abundance of sea-birds and kiore and the absence of other vertebrate predators. Whether cats could have caused the decline of saddlebacks on the mainland is doubtful.

At the time of the decline, rats *(Rattus rattus* and *R. norvegicus)* were the only recently introduced mammals likely to compete with saddlebacks for food. It is now known that kiore eat a wide range of invertebrates as well as fruit and shoot apices of some plants. Thus it is difficult to envisage that the competition for food by rat populations on the mainland would greatly exceed the competition by the dense population of kiore on Hen Island.

The main effect of introduced rats on saddlebacks is likely to have been through predation. Hindwood (1940) records the elimination of 5 indigenous and 2 introduced species of land birds from Lord Howe Island following the introduction of brown rats *(Rattus norvegicus)*. On Big South Cape Island, off Stewart Island, the recent irruption of ship rats has been accompanied by a steep decline in the numbers of South Island robin, Stewart Island fernbird, Stead's bush wren and Stewart Island snipe. There was apparently no successful breeding of saddlebacks there in the 1964-65 season and a count showed that in July 1965 male birds outnumbered females by approximately 3 : 1 (D. V. Merton, pers. comm.), suggesting that females may have been killed on the nest. Guthrie-Smith (1925), after intensive observation of saddlebacks on Big South Cape Island, pointed out that the low nesting height, the small clutch, the slow growth of chicks and retardation of sexual growth, are all factors that make the species vulnerable to rats. Much work on the distribution of rats and their predation on birds is needed but the present meagre evidence suggests that, of the factors considered, European rats are the most likely primary cause of the decline of saddlebacks on the mainland.

Few islands seem suitable as places for transferring the North Island saddleback. Red Mercury Island and Fanal Island (Moko Hinau Group) are possibilities but both lack extensive stands of forest. Cuvier Island is an obvious choice if cats can be exterminated. Islands of the Cavalli group should be investigated. Since saddlebacks feed from the ground, they should not be transferred to the Poor Knights Islands where two species of rail (also ground feeders) make these islands an unusual ecosystem.

The vulnerability of island populations of birds to sudden fluctuations in numbers is well established (Lack 1942). More than 90 per cent. of the bird species known to have become extinct during the last 200 years were of small or isolated islands (Mayr 1942, p. 224). Thus, in the long-term view, transfer of saddlebacks to other islands will not necessarily save the species from extinction. Establishment of saddleback populations on the mainland must be attempted, probably in forest reserves in which some active management of the forest is undertaken to make it more suitable.

SUMMARY OF CONCLUSIONS

1. The North Island saddleback feeds mainly on non-flying invertebrates taken from a wide variety of stations at all levels within the forest. Succulent fruit, buds and nectar are also eaten.
2. On Hen Island saddlebacks probably feed in secondary and coastal forests rather than mature taraire-tawa and pohutukawa-puriri forests.
3. The availability of wood-inhabiting larvae, the nature of the litter and the availability of water are suggested as factors that may influence the distribution of saddlebacks on Hen Island.
4. On Hen Island, kiore (*Rattus exulans*) and more-porks may compete with saddlebacks for food.
5. There is need for further study of all aspects of saddleback ecology if the factors controlling its numbers are to be understood.
6. Island populations of birds are particularly vulnerable to environmental changes. If the saddleback is to be safeguarded permanently, it will be necessary to re-establish stable populations on the mainland.

ACKNOWLEDGEMENTS

The observations of foods and feeding behaviour summarised in this paper are the combined records of 26 members of the 1963, '64 and '65 Hen Island parties. We are indebted to the Wildlife Branch, Internal Affairs Department for organising these expeditions. We are also indebted to Dr. J. A. Gibb for a critical reading of the manuscript.

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A FIELD TRIAL OF A NEW RAT POISON, COMPOUND S-6999, ON BROWN RATS

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INTRODUCTION

The problem of introduced rats endangering the survival of rare birds is a very real one. This is shown by a recent depressingly long list of birds known to have become extinct since 1600, prepared by Vincent (1965) of the International Union for the Conservation of Nature and Natural Resources. Vincent shows that rats and other introduced predators have been directly responsible for the extinction of at least 30 species and subspecies of birds in that time, and probably of twice or three times that number. Several rare species and subspecies of birds surviving on New Zealand's off-shore islands are likewise in danger of extermination by rats.

A recent survey of Big South Cape Island off Southwest Cape, Stewart Island (Blackburn 1965) revealed that six species and subspecies of birds have either been exterminated or driven close to extermination on this island by rats during the past two years. Merton (1965) noted that the black rat *(Rattus rattus)* was responsible.

Following an ecological study of the brown rat *(Rattus norvegicus)* on Mokoia Island, Lake Rotorua (Beveridge and Daniel 1965), the opportunity arose, through the courtesy of the Australian manufacturers, to conduct acceptance trials of a unique new rat poison called "Raticate" which contains 1% of the organic compound S-6999† w./w. in maize. Trials with compound S-6999 (also called norbormide) to control brown rats in the United States have been described by Crabtree *et al* (1964). The present paper describes two acceptance trials with brown rats carried out on Mokoia Island from November 1965 to January 1966.

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† The chemical formula for this compound is:— [5–(alpha–Hydroxy– –phenyl–alpha [2–pyridyl] methyl) –7–(phenyl–2–pyridylmethylene)–5–norbornene–2, 3–dicarboximide]