RESUMES

DIET AND REPRODUCTION OF SHIP RATS IN THE NORTHERN TARARUAS

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INTRODUCTION

The ship, roof or bush rat, *Rattus rattus rattus,* is an introduced species found throughout New Zealand's three main islands and on many offshore islands as well. Now widely recognised as a pest (see New Zealand Department of Lands and Survey Information Series No.4), it has been the subject of only three diet studies (Beveridge, 1964; Best, 1969; Daniel, 1973) and two reproduction studies rDaniel, 1972; Best, 1973). For the present study, I snap-trapped 280 rats in tawa-dominated forest of the Tiritea Catchment Reserve between March 1976 and February 1977 inclusive. I examined the stomach contents of 180 (15 per month) of these, selected using a random numbers table. I calculated the percentage frequency of occurrence of each diet item, and estimated visually whether plant or animal material composed the majority of the volume of contents.

Eight exclosures (each 1 m^2) were placed in Keeble's Bush, near Palmerston North, to determine the importance of the ship rat as a destroyer of fallen titoki *(Alectryon excelsus)* and tawa *(Beilschmiedia tawa)* seed. Four of the exclosures excluded opossums *(Trichosurus vulpecula);* two excluded rats and opossums. The remaining two permitted the entry of all granivores, including mice *(Mus musculus)*. All were covered with fabric to prevent the entry of freshly-fallen seeds during the experiment. They were then left in position for several weeks before the addition of any trial fruits to allow the granivores time to become accustomed to them. Titoki and tawa were chosen as trial fruits because they were available naturally and in large numbers at Keeble's Bush at the time of the experiment. Also, although neither was a preferred food, they were eaten by ship rats in laboratory feeding trials and the typical resultant damage was observed on fruits in the study area. Unbaited smoked paper devices left in the exclosures recorded the footprints of visiting granivores, although there was no guarantee that the recorded tracks corresponded to the seed--destroying species.

All 280 snap-trapped rats were necropsied to check for the presence of sperm in males and embryos in females.

RESULTS AND DISCUSSION

Stomach analysis

Animal foods predominated overall in the stomachs on both frequency of occurrence and majority of volume criteria, but during autumn and winter plant foods predominated. The seasonal frequencies of occurrence of the common diet items are shown in Table 1. Wetas were by far the most frequent single item (76 % of all stomachs). The weta *Hemideina crassidens* was identified in some stomachs, although other species may also have been present. Feathers or eggshell fragments were found in few stomachs (5% and 2% respectively), but except for one record of feathers from June and one of eggshell from February, they were eaten only from September to December, i.e., the bird nesting season. Arthropods eaten included beetles, spiders, ants, moths, centipedes and nymphal cicadas. All 280 stomachs have been lodged in the National Arthropod Collection at DSIR, Entomology Division, Auckland, as voucher specimens.

Exclosures

During a week of daily seed counts, no granivores destroyed significant numbers of titoki fruits. However, if the remnant tracks are reliable, I can conclude that opossums removed all 15 tawa drupes from the two exclosures permitting opossum entry, on the first night of the tawa trial. Exclosure experiments are fraught with potential bias but seed-destruction information is difficult to obtain in other ways.

My observation and experiments with 19 species of fruiting trees, using laboratory feeding trials and

TABLE 1. *The seasonal percentage frequency of occurrence of major food items in stomach contents of ship rats.*

	Spring n = 45	Summer n = 45	Autumn n = 45	Winter n = 43
Weta	55	87	58	59
Unidentified arthropods	27	13	24	26
Lepidopteran larvae	13	29	22	14
Kiekie seed	69	-	-	67
Kawakawa seed	-	20	58	2

exclosures, do not indicate that regeneration is threatened by ship rats.

Reproduction

Adult males with mature sperm were trapped all year round. Excluding a single June pregnancy, no pregnant females were trapped between mid-April and mid-September.

A winter cessation of breeding was reported also by Daniel (1972) for the period 1966 to 1968 in the Orongorongo Valley, Wellington, and by Best (1973) for ship rats trapped from Banks Peninsula and Waimangaroa in the South Island between June 1966 and May 1967. The single pregnant female I trapped in June is interesting, since Daniel (1972) trapped three pregnant females in the Orongorongo Valley in July 1969. Obviously, some rats do breed during some winters, but the extent of such breeding through the population seems to be slight. The mean number of embryos per pregnant female at Tiritea was.4.95 (n = 19). Counting the uterine scars of adult females at the end of each breeding season indicated that females had conceived between zero and four litters each. This variation in reproductive success, combined with an unknown mortality rate, makes any estimate of annual productivity difficult. The fertility of the "average" female in this population can be calculated, in theory, if we accept the assumptions and method of Emlen and Davis (1948). The . calculation gives a fertility of 20.1 young per female per breeding season, which is based on a calculated value of 4.06 litters per female per season. However, considering the evidence from uterine scar counts, I consider that it is unlikely that females averaged four litters per season. Accordingly, annual fertility would in fact be less than the calculated 20.1,young per female.

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COMMUNAL BREEDING OF PUKEKO: DO THE HELPERS REALLY HELP?

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Controversy has arisen over whether helpers in avian communal breeding systems help or whether they hinder (e.g., Zahavi, 1974; Brown, 1978).

Pukeko *(Porphyrio porphyrio),* which were studied in two habitats in the Manawatu between 1970 and 1973 (see Craig, 1974), breed in pairs or in groups. Groups vary in size and may be composed solely of reproducing adults or may have non-reproductive helpers as well. Often more than one female lays in the same nest and most pairs and groups are double-brooded. Thus, pukeko show a range of possible helping situations.

Among groups, adults participate in all breeding activities. Yearlings and chicks of early clutches are permitted to assist with chick care and territorial defence only. While these non-reproductive helpers contribute little to the defence of group territories, chicks may account for up to half the observed defence in pair territories. Also, chicks in pair territories and yearlings in group territories may account for up to half of the observed chick care. Thus, it could be argued that pukeko helpers do help. However, the real test is the effectiveness of this help, one measure of which can be obtained by comparing reproductive success.

Overall, pairs were more successful than groups, but this generalisation does not always apply, as the relative success of pairs and groups was affected by differences in habitat and membership stability. When comparing success of pairs and groups using only those with stable membership and nests surrounded by similar water depths, pairs were still more successful although the differences are no longer significant.

Comparing reproductive success of first and second clutches in pair territories provides a measure of the value of juveniles helping. The comparison suggests that juveniles hinder rather than help, but the results are confused by seasonal effects. Comparison of the reproductive success of groups with and without yearling helpers suggests that yearlings do help.

These results appear to add to both sides of the controversy. However, a full evaluation of the communal breeding strategy of pukeko requires consideration of other factors including habitat differences in social organisation (Craig, in press).

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THE RELATIVE EFFICIENCY OF ENERGY AND NITROGEN UTILISATION IN LEAFCUTTER BEE LARVAE

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Megachile pacifica (Panzer) is a leafcutter bee of the family Megachilidae. It belongs, with ants (Formicidae), honey bees (Apidae), and wasps (Vespidae) to the order Hymenoptera. This species is palaearctic in origin but was accidentally introduced to North America where it pollinated Lucerne (*Medicago saltiva* L.) flowers. It has been specially introduced to New Zealand for the same reason. Its common name refers to its habit of cutting out pieces of leaf with which it constructs brood cells. These cells are about 10 mm long and 4 mm wide and are made of 20 or more pieces of leaf. The female provisions a cell with pollen and nectar on which she lays a single egg before closing the cell with leaf discs. In the commercial situation female bees are provided with nest boxes which simulate a series of hollow stems which are the natural nest site of this species.

This paper discusses the efficiency with which the larvae that subsequently hatch from the egg utilise the food plug. The experimental procedures and full results are in Wightman and Rogers (1978).

One of the many ways of comparing organisms is to rank the efficiency with which they convert food into body tissue during a phase of growth. Clearly, the larvae of the leafcutter bees are in an "ideal" situation in that they live in an environment buffered from extremes and do not have to expend energy to seek food. Indeed. when the ecological efficiencies of M. *pacifica* are compared with those of a range of terrestrial arthropods. it can be seen that this supposition is true (Table 1).

The only arthropods that apparently have a higher assimilation efficiency than M. *pacifica* larvae are web-spiders. This is because they imbibe the pre-digested soft parts of their prey avoiding the energy-expensive process of breaking up tough

TABLE 1. *Comparison of the efficiency of energy utilisation* in 5 *species of arthropod.*

	200 A/C Assimilation efficiency	100 P/C Gross biological efficiency	100 P/R
Megachile pacifica larva	87.5	38.5	201.5
Seed beetle larva *(Callosobruchus analis)*	85.0	49.9	141.8
Web spider *(Gedycosa godeffroyi)*	89.1	39.5	-
Leaf-eating weevil *(Odontopus caeceatus)*	51.0	11.0	27.3
Dung beetle larva *(Aphodius rufipes)*	8.9	3.1	54.0

Where C = energy content of food consumed.
P = energy content of fully-grown larvae plus secretory products and cast skins.
R = energy expended to fuel the metabolic processes.
A = the energy content of assimilated food (P + R).

exoskeletons prior to internal digestion. The seed beetle larvae *(Callosobruchus)* live in dried peas and so, like *M. pacifica* larvae, live in their food, but unlike them have a more refractory food source, hence their lower gross biological efficiency and P to R ratio. The data for leaf-eating weevils are typical of herbivorous beetles and caterpillars. The relatively low gross biological efficiency and P: R ratio reflect the continuous need of animals with this life style to move around seeking new sources of food. Dung beetle larvae *(Aphodius* spp.) are among the least efficient arthropods yet investigated, not because of a physiological deficiency but simply because they live in a medium that has already passed through the efficient digestive system of a cow. Even though they have little need to move around, their food source is so poor in digestible energy that they have to consume large quantities, compared to the larvae of leafcutter bees, in order to extract sufficient nutrient to promote growth.

Unfortunately, there is little information about the ability of arthropods to convert food nitrogen (equivalent to protein) into body nitrogen comparable to the data of Wightman and Rogers (1978) (Table 2).

The data (Table 2) show that the hymenopterous larvae are more efficient than caterpillars feeding on mulberry leaves, and the familiar stored-product beetle.

These results show that the energy-expensive procedures of building and provisioning cells carried out by female leafcutter bees are compensated for by the efficiency with which the larvae convert food into body tissue.

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TABLE 2. *Comparison of the efficiency of nitrogen utilisation of three species of insect.*

	100 A/C Efficiency of N assimilation	100 P/C Gross biological efficiency of N conversion
M. *pacifica*	87.0	87.6
Silkworms *(Bombyx mori)*	63	60
Tenebrio molitor	55	-

Where A, P and C are defined as in Table 1; substitute nitrogen for energy.

THE RELATIONSHIP OF GEOLOGY AND SOILS TO EROSION IN THE SOUTH-EASTERN RUAHINE RANGE

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This paper summarises our current studies aimed at determining the influence of soils and geology on the natural and accelerated erosion in the southern Ruahine Range. Increased bedload levels and resultant increased liability to flooding are major problems in catchments downstream of the eastern front of the range. Our studies, financially supported by the National Water and Soil Conservation Organisation and the New Zealand Forest Service, are part of a wider programme in which many agencies are investigating the many aspects of the current erosional situation.

GEOLOGY

Within the bedrock (Torlesse Supergroup) along the eastern front of the southern Ruahine Range, we recognise two lithotypes: an "easternmost lithotype" which consists of massive alternating sequences of bedded sandstone and mudstone and a "westernmost lithotype" which comprises an assortment of sedimentary and volcanic rocks that "float" in a matrix of black argillaceous material. Clasts range in size and shape from elongate lenses tens of metres in diameter, to rounded granules (two to four millimetres in diameter). On the basis of parallel outcrop trend and an essentially transitional contact (where it is not locally faulted), both lithotypes are considered conformable. The regional strike is NE to NW. A westward younging direction and steep dip, essentially to the east, indicate that the strata are overturned.

Deformation during two mountain-building periods has flexured, folded, faulted, uplifted and tilted the bedrock. These processes have produced:

1. a steep eastern range front into which drainage channels have incised deeply to form very steep-sided narrow valleys, and
2. an aligning of the strata parallel to this steep front with the dip direction coinciding with the down-valley slope.

Two major fault zones parallel the general strike of the range and are related to the tectonic movements that shaped it. Fault trenches and scarps of the Mohaka Fault, along the base of the range, cut through Quaternary sequences indicating that movement continued well into the Late Quaternary, The Ruahine Fault Zone is delineated by extensive exposures of fault'-Crushed rock and pug in the westernmost lithotype.

This combination of geological factors has rendered the eastern greywacke lithotypes prone to erosion. Triggering mechanisms such as intense rainstorms and earthquakes have no doubt initiated deep-seated geological failures that have resulted in erosion in the upper parts of the eastern catchments.

SOILS

An investigation of the soil resources of a selected subcatchment in the West Tamaki River, and their relationship to the erosion pattern, has indicated four main soil classes with associated vegetation types:

1. At lower elevations, on interfluves and gently sloping toeslopes, a deep, friable loessial soil, related to the Dannevirke series, is found occurring under a podocarp-broadleaf forest. The sand and clay fractions of this soil indicate that it has developed from a loess, contaminated with a large volcanic-ash component.
2. With increasing elevation, the soils of the interfluves grade into Takapari hill soils, in an area dominated by dead and dying kamahi *(Weinmannia racemosa)* trees. These soils also have a significant loessial component, but are more poorly drained, with iron and aluminium mobilised in the profile.
3. On the unstable steep to very steep slopes of the subcatchment, poorly-developed, weakly-weathered Ruahine steep land soils exist, often with buried horizons. The vegetation in this area is frequently severely damaged by erosion scars, with only the occasional mature podocarp evident.
4. On the summit plateau of the southern Ruahine Range, at the head of the catchment, a peat-the Takapari peaty loam-has formed under a dense leatherwood *(Olea ria colensoi)* vegetation.

RELATIONSHIP OF SOIL PARAMETERS TO EROSION SITES

Most of the deep-seated erosion occurs in the zone in which the Takapari hill soils occur. Saturated hydraulic conductivity studies of these soils suggest that a perched water-table may develop at the junction between the Ah (or Ha) and Bg (or Br) horizons (FAO/UNESCO horizon designations), with interflow of water through the surface peaty horizons. This perched wate~table creates a saturated zone, with a consequent decreased shear strength, acting as a plane of weakness for mass movement to occur.

At lower elevations, more superficial erosion occurs in the area in which Ruahine steep land soils form. Here it is probable that the erosion, which invariably occurs on north-east facing slopes, can be attributed in part to the structural weakness of the soil, together with other factors such as steepness of slope, geology and aspect.

SUMMARY OF THE MAJOR LATE QUARTERNARY DEPOSITIONAL EVENTS WITHIN THE WEST TAMAKI RIVER CATCHMENT

1. About 20000 yr B.P. the Aokautere Ash was deposited on the main channel valleyside, 10 m above the present river bed. This indicates that aggradational gravels were no higher than this point, at that time.
2. An extensive fan at Whiteywood Creek records at least three periods of active aggradation. The two most recent periods have been radiocarbon dated at 12 150 ± 150 yr B.P. (NZ4314B), and 770 ± 60 yr B.P. (NZ4547C).
3. A fan deposit at Stanfield Hut is tree-ring dated at 88 years old by the red beech *(Nothofagus fusca)* stand, (P. J. Grant, *pers. comm.)*.
4. More recent erosion events are indicated by fan deposits and associated terraces at the mouths of Car Park Creek and No. 1 Creek. (These are considered to be more recent on the basis of soil development and vegetation maturity).
5. A set of terraces with an essentially bare gravel surface indicate the most recent significant erosion and resultant depositional event-Cyclone Alison, of March 1975.

BREEDING OF THE SHINING CUCKOO AT KOWHAI BUSH, KAIKOURA

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At Kowhai Bush near Kaikoura (South Island, New Zealand) in the summers of 1976-77 and 1977-78, I examined periodically 17 nests of the grey warbler *(Gerygone igata* Muscicapidae: Acanthizinae) which were parasitised by the shining cuckoo *(Chrysococcyx lucidus lucidus* Cuculidae: Cuculinae). Shining cuckoos breed in New Zealand after migrating from the Solomon Islands. Where they reside from March/ April to August/ October (Mayr, 1932).

Grey warblers (see Gill, 1978) are double-brooded, laying first clutches from late August to October and second clutches from late October to December. Most cuckoos arrive in New Zealand during late September and early October (Cunningham, 1955), so that they usually parasitise only the warblers' second clutches. Most cuckoo eggs were laid in mid- or late-November, about eight weeks after the peak of migration. The delay is hardly surprising since it follows a flight across sea of some 3 000 km. The frequency of parasitism was 55 % of late clutches.

Cuckoos laid only one egg per nest. The nest is enclosed and the young cuckoo grows to fill it. Cuckoos apparently removed a warbler egg during the act of parasitism, since the total clutch-size was unaltered by addition of the cuckoo's egg. The egg (immaculate olive-green) is not mimetic of that of the host (white with red-brown speckles), suggesting that the warbler cannot discriminate alien eggs, perhaps because the nest is too dark inside. However, the two types of egg are similar in weight and dimensions, which has involved reduction of the cuckoo's egg to 7 % of the adult's body-weight. For cuckoos in general this is the least that eggs are reduced, c.f., eggs of *Cuculus canorus* which are only 2 % of the adult's body-weight (Lack, 1968).

Grey warblers usually lay a clutch of four and produce eggs at 48-hour intervals. Cuckoos deposited their eggs as early as the day on which the warbler laid its penultimate egg, or as late as 7-10 days after completion of the warbler's clutch. The laying of some eggs so late suggests inefficiency in parasitism. Shining cuckoos are specialists (I have good evidence for a single mainland host) and the host is territorial and breeds asynchronously. Female cuckoos presumably search widely for nests and evidently encounter some difficulty in finding them.

The number of eggs that a cuckoo lays in one season, divided by the frequency of parasitism, all multiplied by the average a,rea of a warbler territory, gives the minimum area that supports one female cuckoo in her reproductive activities. Payne (1973) showed, from histological examination of ovaries, that *Chrysococcyx caprius* of southern Africa lays 1.3-1.8 eggs/week throughout the season. If this figure (the best available for the genus) holds for shining cuckoos, which lay during 10 weeks, then each female produces about 14 eggs/season. These eggs reach 55% of late warbler nests situated in territories of 0.68 ha on average. Therefore, each female shining cuckoo probably needs exclusive use of about 20 ha at Kowhai Bush.

Most cuckoo-eggs were laid just after completion of the host's clutch, but the cuckoo's incubation period is four days less on average than the host's, so that in most cases cuckoos hatched before any warblers. Nestling cuckoos evicted all eggs or young of the warbler, but did not do so until 3-7 days old, by which time some warblers had hatched in most nests. Inter-specific competition for food, however brief, was common initially. The cuckoo has a large flat back *(c.,* 2.5 cm^2 at 5 days old), bilaterally paired spinal pterylae (d., one median tract in passerines), and a tendency to hold the wings out stiffly until 8-9 days old. These may be adaptations for eviction.

For its first 10 days a nestling cuckoo was equivalent in terms of weight to a brood of two warblers, and it left the nest equivalent to a brood of three. However, warblers often successfully raise four of their own young. The effects of parasitism on the long-term survival of the host are probably negligible. Of all eggs laid by warblers (both clutches) which failed to hatch, only 22 % were destroyed by cuckoos. Only 17 % of all nestling warblers which failed to fledge were evicted. Warblers suffer other important causes of mortality, especially predation by introduced mammals. Parasitism causes little or no reduction in recruitment of early young, and only 17 % of *late* warbler-eggs were prevented by parasitism from giving rise to fledglings.

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KEEBLES BUSH, PALMERSTON NORTH-A LOWLAND FOREST REMNANT. HOW SHOULD IT BE MANAGED?

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When Mr C. T. Keeble died in 1971 he bequeathed 15 hectares of bush, just south of Palmerston North, to a Trust Board, which he charged, in terms of his will, with "the preservation in perpetuity of the said area as a specimen and example of primitive and undamaged Manawatu Rain Forest both for study and observation and for that purpose to restrict entry to the said area so as to prevent damage or spoilation of the plant life thereon". He stipulated that the bush should be securely fenced and handed over to the Board with all survey and other expenses paid, but there was no provision for any finance for maintenance.

During his lifetime Mr Keeble had carefully preserved the bush free of domestic stock and human interference. In 1936 a gale severely damaged parts of the bush, and the drought of 1969-70 caused a number of deaths, particularly of the canopy trees *Dacrydium cupressinum* and *Beilschmiedia tawa,* (Atkinson and Greenwood, 1972). Nevertheless, the bush is the best surviving remnant of the mixed podocarp-broadleaf forest that once covered almost all of the drier Manawatu lowlands. It contains many more species than any other remnant (Esler, 1962) and in parts still retains much of the original canopy and structure of the bush. However, in many parts the original canopy has been modified or destroyed, and the vegetation is in a dynamic state, of interest and value for detailed study, but very vulnerable to modification.

Delays in carrying out terms of the will have meant that 7t years after Mr Keeble's death the Trust has not yet been set up, but it is hoped that it will be during 1979. The Board will be faced with many problems which we feel are typical of the conservation/preservation/restoration type of issue facing those called on to administer lowland forest remnants.

Lack of finance could possibly be overcome by public donations, but this would probably bring with it a greater freedom of public access to the bush, and raises the question of how much access should be allowed? Examples of deterioration from unrestricted public access are clearly shown by the Esplanade Bush in Palmerston North, and Kitchener Park near Feilding, with gross modification of and loss of species from the shrub and ground layers in particular.

A few species known to have been present originally in Keeble's Bush appear to have been lost, e.g., *Fuchsia excorticata* and *Eugenia maire;* should these be reintroduced? Should species now present in very low numbers, e.g., *Metrosideros robusta,* be propagated and planted in suitable sites near the margins or other modified areas so that the species are not lost in the bush? What about species, e.g., *Hoheria angustifolia* and *Carmichaelia flagelliformis,* not known to have been present in the bush but now surviving precariously in other local remnants? Should they be introduced to guard against their local extinction?

What should be done with the pines planted many years ago in a belt along the western margin to provide protection from the prevailing winds? These are now mature, overtop the bush canopy, are open and draughty underneath, and their overhanging branches threaten to damage the fence. Should they be removed, and if so what should be done with the land, possible two hectares, on which they are growing?

Several aggressive weeds have become established in the bush. The worst of these is *Tradescantia fluminensis,* which is capable of forming a dense carpet over the forest floor, excluding almost all other plants. Should an attempt be made to eliminate this and other serious weeds, e.g., *Lonicera japonica?* This would necessitate much hand-weeding, and spraying of the denser patches, which would itself cause modification of the ground vegetation. Where removal of dense patches of weeds leads to gaps in the vegetation should fast-growing species e.g., *Aristotelia serrata* and *Hebe stricta* be planted to prevent re-establishment of weeds?

Should an attempt be made to reduce opossum *(Trichosurus vulpecula)* numbers? They are probably responsible for the loss of *Fuchsia excorticata* and *Eugenia maire* and threaten other important species, e.g., *Weinmannia racemosa*. The bush is surrounded by farmland with little cover for opossums, so re-invasion of the bush from outside might be slow.

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INTER-RELATIONSHIPS OF FERAL STOCK, SEA BIRDS AND VEGETATION ON CAMPBELL ISLAND*.

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Campbell Island (52° 33'S, 169° 08'E) is the southernmost of New Zealand's island reserves. The island's flora and fauna have been much exploited and modified. Of the introduced mammals, sheep *(Ovis aries),* cattle *(Bos taurus),* cats *(Felis catus)* and rats *(Rattus norvegicus)* are still present. Rats are ubiquitous and as a result few of the burrow-nesting seabirds and no Campbell Island teal *(Anas aucklandica nesiotis)* are now found breeding on the main island. However, the island is an important breeding location for many other seabirds and is the main breeding ground of the southern royal albatross *(Diomedea epomophora epomophora).*

In 1895 a sheep station was established. Sheep numbers peaked at 8500 in 1910, but by 1931, when the uneconomic venture was abandoned, only about 4000 sheep remained. Westerskov (1959) advocated removal of the sheep. Wilson and Orwin (1964) counted only 1000 sheep in 1961 and thought they would continue to decline, but in 1969 3 000 sheep were counted (Taylor, Bell and Wilson, 1970). Calls for removal of the sheep were renewed. Taylor (1968), however, had warned that removing introduced animals from an environment where they had long been present might not result in a return to former conditions; he showed that on some islands this had led to unexpected and undesirable changes.

In January/February 1970, the fence proposed by Wilson and Orwin (1964) was built and the feral sheep on the northern half of the island were shot. A research programme with the following main aims was adopted (Taylor, 1977):

1. To help determine how best to manage the island's vegetation and wildlife. Thus, the idea of removing sheep from one half of the island was partly to avoid a hit-or-miss approach to the sheep /vegetation question.
2. To remove immediately any threat by sheep to the survival of any plant species or communities on the island.
3. To measure the effects of sheep on vegetation, soil erosion and bird life; and to isolate these from other, perhaps more fundamental, changes affecting the flora and fauna.
4. To allow further study of the biology, population ecology and agricultural value of the long-isolated feral sheep and cattle.

Sheep continued to increase south of the fence, from 2088 in 1969 to 2521 in 1971 and, after a decline to 2400 in 1976, increased to 2861 in 1977 and 3 175 in 1978. Breeding pairs of royal albatrosses numbered 2278 in 1958, 4344 in 1969, 5336 in 1976, 4906 in 1977 and 4208 in 1978. The number of feral cattle decreased from 20 in 1971 to 11 in 1977 and 1978 (Dilks and Wilson, in press; Dilks and Dunn, 1978). The cattle are confined to one comer of the island; an area which has limestone under the peat mantle.

The reason for the continued increase in sheep since 1961 is unclear. There is little evidence that a change of climate !has been responsible. One possibility is that, because of natural selection, a variety of sheep better capable of surviving the Campbell Island environment has evolved.

The royal albatross population is probably recovering from early exploitation. However, if sheep had been removed completely this increase may have been attributed to the lack of sheep. The drop in royal albatross numbers breeding in 1977 and 1978 occurred both north and south of the fence and, had sheep been left all over the island, would probably have been regarded as a cones-quence of their population increase. These examples illustrate the scientific value of the removal of the sheep from one half of the island.

The drop in cattle numbers may be related to increased competition with sheep. The reason cattle are confined to the area of the island with a limestone substrate may be because it is less boggy, but copper deficiency away from this area is also a likely reason. Sheep livers collected from the cattle range averaged over six times more copper than those collected elsewhere.

Since sheep were removed there have been some spectacular vegetation changes north of the fence. Formerly close-grazed sward is now rank grassland. The highly palatable herbaceous species such as *Pleurophyllum* spp., *Anisotome* spp., and *Stilbocarpa polaris,* whose range had been much reduced by sheep, are now common. *Chionochloa antarctica,* a palatable tussock, is recolonising, and in some areas

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at least will probably soon regain dominance over the less palatable *Poa litorosa*.

Since their removal from the northern half of the island, sheep no longer threaten the survival of rare plants or plant communities. The sheep / fence experiment needs to run another 10 years before well-founded predictions can be made on the effect of complete sheep removal.

The keeping of sheep on half the island is helping the identification and investigation of trends in vegetation and animal populations that are *not* associated with the presence of browsing of sheep, e.g., an increase in seabird populations because of changes in their food supply.

The issue of whether sheep should be removed or kept on the southern part of Campbell Island should not be given inflated importance while overlooking other conservation problems. Introduced cats and Norway rats are a far more serious threat to the island's status as a fauna and flora reserve and their removal poses a much greater challenge to conservation research and management.

Research into the biology of the sheep, both on Campbell Island and at Ruakura, has been of value to agriculture. Further studies on such subjects as sheep behaviour and ecology are desirable and can only be carried out at the island.

Feral sheep have potential agricultural value in their genetical make-up since they have evolved under natural selection pressures. Campbell Island sheep would be of most value for their genetic diversity and studies of evolutionary characters if kept on the island where natural selection would continue. These principles were recognised at the symposium on the value of feral farm mammals in New Zealand (Whitaker and Rudge, 1976).

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