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INTRODUCTION

New Zealand has a multiplicity of challenging animal-control problems, and all of them concern animals which man has intentionally introduced either for sport, food or fur (Table 1).

TABLE 1. INTRODUCED MAMMALS ESTABLISHED IN NEW ZEALAND. ADAPTED FROM WODZICKI (MS).

<u>ORDER AND SPECIES</u>	<u>DATE FIRST INTRODUCED</u>	<u>DISTRIBUTION</u>	<u>ABUNDANCE</u>	<u>DEGREE A PROBLEM</u>
<u>MARSUPIALIA</u>				
Brush-tailed Opossum <u>Trichosurus vulpecula</u>	1858	Widespread	Abundant	Acute
Common Scrub Wallaby <u>Wallabia rufogrisea</u>	1870	Restricted	Rare	Moderate
Swamp Wallaby <u>W. bicolor</u>	1870	Restricted	Rare	Minor
Black-striped Wallaby <u>W. dorsalis</u>	1870	Restricted	Rare	Minor
Dama Wallaby <u>Protemnodon eugenii</u>	1870	Restricted	Rare	Minor
Black-tailed Rock Wallaby <u>Petrogale penicillata</u>	1870	Restricted	Rare	Minor
<u>INSECTIVORA</u>				
Hedgehog <u>Echinaceus europaeus</u>	1892 ?	Widespread	Abundant	Minor
<u>CARNIVORA</u>				
Stoat <u>Mustela erminea</u>	1885	Widespread	Common	Moderate
Weasel <u>Mustela nivalis</u>	1885	Restricted	Rare	Minor
Ferret <u>Putorius putorius</u>	1882	Restricted	Common	Minor

RODENTIA

Ship Rat <u>R. rattus</u>	18th Century	Widespread	Common	Moderate
Norway Rat <u>R. norvegicus</u>	Early 19th Century	Widespread	Common	Acute
Mouse <u>Mus musculus</u>	Early 19th Century	Widespread	Abundant	Acute

LAGOMORPHA

*European Hare <u>Lepus europaeus</u>	1867	Widespread	Abundant	Acute
European Rabbit <u>Oryctolagus cuniculus</u>	1836	Widespread	Abundant	Acute

ARTIODACTYLA

Goat <u>Capra hircus</u>	18th Century	Widespread	Common	Acute
Chamois <u>Rupicapra rupicapra</u>	1907	Widespread	Common	Acute
Thar <u>Hemitragus jemlahicus</u>	1904	Restricted	Common	Moderate
Red Deer <u>Cervus elaphus</u>	1851	Widespread	Abundant	Acute
Sambar Deer <u>C. unicolor</u>	1875	Restricted	Rare	Minor
Javan Rusa Deer <u>C. timoriensis</u>	1907	Restricted	Rare	Minor
Wapiti <u>C. canadensis</u>	1905	Restricted	Common	Minor
Japanese Deer <u>C. nippon</u>	1885	Restricted	Common	Moderate
Fallow Deer <u>Dama dama</u>	1864	Restricted	Common	Moderate
Moose <u>Alces americana</u>	1900	Restricted	Rare	Minor

ARTIODACTYLA (Cont'd.)

Virginia Deer <u>Odocoileus virginianus</u>	1901	Restricted	Common	Minor
Pig <u>Sus scrofa</u>	18th Century	Widespread	Common	Acute

Indicates species considered to be an important "problem animal" in alpine grass lands.

Since the beginning of European settlement in the 19th Century, approximately 53 species of mammals and 125 species of birds have been deliberately or accidentally introduced into New Zealand, and 34 birds and 31 mammals have become established (Wodzicki, 1950). The principal reasons the exotic big game animals (Riney, 1955), fur bearers and feral domestic livestock have been so destructive to certain habitats in New Zealand are because 1) some of the soils are highly susceptible to erosion, 2) the mountainous country often gets high intensity torrential rainfall, and 3) many of the endemic plants have little innate resistance to the heavy selective grazing or browsing pressure.

The bulk of New Zealand's vegetation is composed of indigenous species. This unique flora must have evolved without the presence of browsing or grazing mammals, for New Zealand has no fossil or native land mammals, except two species of bats and a rat that was liberated a few centuries ago by the Polynesians. Consequently, natural selection did not have an opportunity to eliminate the highly palatable and non-browse-resistant plants in favor of those which were either browse-resistant or unpalatable to browsing mammals. As a result, some of the highly palatable indigenous vegetation in New Zealand is unable to withstand the heavy selective browsing and grazing pressure inflicted by the introduced mammals (Holloway, 1950, Howard MSa and MSb, Kean and Pracy, 1949, McKelvey, 1959, Riney et al., 1959, Wardle, 1961).

RABBIT AND HARE

New Zealand has done a good job of bringing rabbits under control (Fennessy, 1958, Howard, 1958, Shennan, 1960, Thompson, 1958). But this accomplishment has been and still is costly--currently about four million dollars a year, which is equal to an annual expenditure of about six cents for every acre of land and almost one and one-half dollars for every person in New Zealand.

It seems advisable to abandon the current control program aimed at complete eradication of rabbits, at least until better control methods are developed. An extermination program has been fairly tried, and it has failed in all areas. The objective now should be to achieve economic control, which is the reduction of the density of rabbits and hares to a level where undue amounts of damage do not occur, i.e., to a tolerable level where the cost of control is reasonably proportionate to the damage these animals cause (Howard, 1963a, 1963b).

New Zealand's first Rabbit Nuisance Act was established in 1876. It enabled the formation of local Rabbit Boards and for rates to be levied on the landowners. The owners were responsible for rabbit control, but the Boards could send control teams on to the land of defaulters. These first Boards had many weaknesses and were abolished in 1882, when weasels, stoats, and ferrets were introduced, in the mistaken belief that they would control the rabbits (Thompson, 1958).

Rabbit Boards were re-established in 1886 and the Government offered to provide matching funds to that raised by levies against landowners. Since that time there have been many legislative changes enacted, of which the 19⁴⁷ Amendment is the most significant. One important part of this act was the devaluation of the rabbit. It was necessary to stop the export trade of rabbit skins and meat so no one would have an economic incentive to encourage the protection of rabbits. This Amendment also established an eight member Rabbit Destruction Council, which "has had a stormy history, for it met bitter opposition to the formation of new Rabbit Boards, not only from the commercial rabbiters but from the run-holders who depended on them for both rabbiting and seasonal labor for mustering and shearing. Many landholders objected to the payment of rates, and it is a tribute to the vigor and persistence of the Council, and especially to the inspiring leadership of their chairman, Mr. George Bart Baker, that the attitude to the rabbit throughout New Zealand has almost completely changed. From being an article of commerce, the rabbit is now accepted as a valueless pest" (Thompson, 1958).

Every conceivable approach has been employed in New Zealand to control rabbits. Rabbit-proof fences up to 80 miles in length were constructed, but fencing has proved ineffective except with small areas. Other methods tried include traps, night shooting, smoking and gassing of burrows, dogging with gun and cyanogas or chloropicrin, ferrets, mechanical ripping of warrens and poison baits. Myxomatosis, the disease which was so successful in Australia, did not work in New Zealand, presumably because there were not enough mosquitoes.

Poisoning has proven to be the most successful method. Strychnine was popular when there was a skin trade, because it is quick acting and the rabbits died at the baiting sites, hence were easily recovered. Arsenic-treated chopped carrots or grains were once used widely in South Island. Phosphorus has been used extensively in pollard pellets and also in jam baits, especially in North Island. The most successful toxicant for rabbit control on large holdings away from heavy settlement has been sodium fluoroacetate, commonly called 1080 (McIntosh, 1958).

It is standard practice with large-scale control operations to generously prebait or free-feed the rabbits two or more times at intervals of several days or longer before any toxic baits are put out. Chopped carrots are the most effective bait material and many thousands of tons are used annually for rabbit control.

One area of about 250 acres at Waikoikoi, South Island, which I visited on several occasions in 1957 indicates how numerous rabbits can become under favorable conditions. This high population of rabbits was poisoned by the Department of Agriculture that same year, and they kindly supplied me with a

report of the operation. Most of the rabbits lived within an area of less than 100 acres, but the entire feeding territory approximated 250 acres. Light furrows were made to mark the baiting lines. Pre-feeding with chopped carrots was done on July 18 and 23. Then a snowfall lay on the ground for one week, so pre-baiting was done a third time on August 10. On August 12 about 1,680 pounds of chopped carrots treated with 0.0324 per cent 1081 (sodium fluoroacetamide) was distributed. During the next three days 4,286 dead rabbits were picked up. Since an earlier experiment with 1080 had showed that about 1/3 of the rabbits die below ground (Wodzicki and Taylor, 1957), it can be assumed then that more than 6,400 rabbits (about 3.8 rabbits per pound of poisoned bait) were probably poisoned in this operation.

Hares are controlled to some extent incidental to rabbit control operations, but they travel greater distances and are more difficult to cope with. Fortunately, they do not become as numerous per unit areas as rabbits, although they still are a serious problem species in some areas. No effective control of hares has been developed for the alpine grasslands, where their control also is often needed.

DEER AND OTHER BIG GAME

Nine species of deer, moose, chamois, and thar were introduced for sport and Batchelor (1962) reports that there has been at least 237 initial releases and subsequent transplants made, principally of red deer. The origin of the feral goats and pigs goes back to Captain Cook (1769) and crews from ships in pursuit of seals and whales. Four species of Australian wallabies were introduced and several local populations of wallabies are considered as serious pests. They are being controlled by poison bait and shooters with dogs. Chamois and thar primarily have been controlled by shooting, although limited success has been achieved in aerial poisoning of thar with carrots and 1080.

There have been two main periods in the management of the introduced ungulates. According to Wodzicki (1961), there was "an initial period of protection and a later one of attempted control. In both periods prevailing interests shaped and dictated policy. The first period followed the liberations of the various species and lasted until about 1930. Initially there was complete legal protection, and in later years partial protection--e.g. deer were shot under licenses issued by the acclimatisation societies, and in later years shooting of unthrifty animals in certain deer herds carried out by these societies."

A report by Mr. R. Fraser (then Officer-in-Charge, Noxious Animals Division, New Zealand Forest Service) to the Minister of Forests summarizes well the history of the deer-control activities. Quoting from Batchelor (1962), Fraser wrote: "As a result of the public agitation leading to the 1930 conference, a country-wide survey of deer-infested areas was made. Government control operations were initiated in 1931 under the Department of Internal Affairs, and a deer-tail bounty then being paid was continued.... As field techniques were developed and staff trained in this new field, campaigns were progressively increased until 1939.

"As an encouragement to private deer hunters a deer-skin market was developed and the Department of Internal Affairs bought skins from hunters and marketed them overseas. Once this market was well established the Government

ceased buying and the trade was left in the hands of private hunters. The Government still marketed skins obtained from its own hunting activities. Later, this collection of skins was stopped because it held up to a considerable extent the killing of animals. As an example of the great contribution then being made by private hunters, of the 100,935 deer skins exported in 1944, 6,323 only were obtained from Government operations Although the first operations gave relief to pastoralists (they were primarily directed to this objective), it was early on recognized that the principal threat was to soil and water conservation in the upper catchments of the main rivers. Control policy was based mainly on this concept and campaigns were directed towards this end....

"As control operations developed, other animals, such as thar, chamois and goats, were brought within the scope of operations as the effect... of these animals on forest and alpine vegetation was realized. Thar and chamois were included in deer campaigns from 1935 and goats from 1937. Goats in open country are largely an economic problem because the animals are in competition with domestic grazing stock. In forests, however, their impact on regeneration is similar to, if not more severe than, that of deer.

"The organization during the war years was seriously affected, with consequent loss of much of the ground gained up to 1939. From 1946 a progressive build-up was commenced, and the organization eventually reached a hunting force of between 100 and 125 men. During this period increasing demands for control measures on various animals were made by different organizations, public bodies, and Government Departments. Field-investigation and research teams were established and a Noxious Animals Advisory Committee consisting of the various Government departments concerned with noxious wildlife problems, was set up. In 1952 on account of the increasing demands and the impossibility of meeting all these with the force of skilled hunters available, a policy of selection of operational areas on a priority basis was introduced... (For more on priorities see Riney, 1956).

"Control of noxious animals came under the N. Z. Forest Service on 1 April 1956. This involved the transfer, virtually intact, to the Service of what was known as the Deer Control Section of the Wildlife Division of the Department of Internal Affairs. It included a small team of research officers working at that time on noxious animals.

"A separate act was passed, known as the Noxious Animals Act, in 1956. This permitted, amongst other things, the hunting and killing of the noxious animals...; the powers of entry on the land for this purpose; it prevented the ownership for liberation of noxious animals and it permitted local bodies to raise funds and carry out destruction."

Until recent years, shooting has been the only effective method for controlling red deer. In much of the fairly open, easy country this method is quite effective, but in remote, rugged, mountainous terrain it has proven difficult to hold deer populations very far below the carrying capacity by either or both paid and private hunters. By Government decree all of the ungulates are considered noxious, hence not protected. No license is required and anyone may shoot or otherwise destroy as many animals as he wishes.

In some localities, a new animal-soil-vegetation stability has evolved and animal control is no longer required. In other areas, even if all of the ungulates could be removed, many years still would be required before the soil could again be stabilized. It is clear that in many of the problem areas, more effective methods of animal control are needed. Poison baits also are being used (Daniel, 1962). One successful poison bait for deer consists of 0.05 per cent 1080 on chopped carrots (Batchelor, 1962, McKintosh, et al. 1959, Poole, 1962). This has been effective, however, only where deer first can be driven by summer shooting teams into a more or less restricted winter range, where poisoned carrots can then be dropped from airplanes. Sufficient deer control by intensive shooting is being attempted in one watershed of the Urewera National Park (Vipond, et al. 1962a and b), to see if it is possible to protect the sensitive, highly palatable plants.

Habitat stability, whether by reseeding, game management, or animal control, should be the primary objective where introduced big-game animals in New Zealand have upset seriously the soil-vegetation stability of the original communities. The animals cannot be eradicated, except locally, and it is futile to attempt to re-establish the original vegetation composition with these animals present. The species composition of the flora has been altered irreversibly in many areas, although no species of plant has been eliminated completely (Howard MSb).

BRUSH-TAILED OPOSSUM

The Australian brush-tailed opossum was introduced for fur. Between 1837 and 1911, more than 180 individuals were imported from Australia and 469 subsequent transplants have been documented (Pracy, 1962). Opossums rarely produce extensive soil erosion by themselves; however, after deer and other ungulates first open-up the forest floor, these browsing marsupials then often become sufficiently numerous to kill many kinds of large, mature trees (Holloway, 1959, Kean and Pracy, 1949, Pracy and Kean, 1949), hence need to be controlled. Opossums can be a serious nuisance to home owners; they often short circuit power lines unless metal shields are installed on the poles; sometimes they damage swedes and turnips being grown for sheep; willow trees planted to prevent erosion in river catchments sometimes are killed by being completely defoliated; opossums often destroy young conifers; and sometimes they need to be controlled along the edge of clover fields adjacent to forests or bush, in orchards and in gardens (Howard, 1963a).

In April 1961 a bounty on opossums of 35 cents was removed because it had failed to control the pest. During the ten years in which the bounty operated, about three million dollars was paid for eight million animals. Another four million skins were taken during the same period. Most opossum control is now done by rabbit board personnel (Poole, 1961).

Control methods with opossums have consisted of snares, dogs and guns, steel traps and poisons, with trapping and poisoning being the principal control methods. The main poisons used have been either phosphorus, potassium cyanide, or 1080 in jam or pollard-molasses pellet baits containing aromatic lures such as oil of aniseed, eucalyptus, and roses. Another effective ground-laid bait has been flour and lure. A special cyanide bait is now packaged in a tube that looks like an over-size tube of toothpaste.

WILD GOAT AND PIG

Feral goats and pigs are widespread in New Zealand, even though goats spread their range slowly (Riney and Caughley, 1959). They have been very destructive to native vegetation, both grasslands and forests. The greatest damage from pigs is due to rooting, which destroys livestock feed and causes accelerated erosion in the mountains, but they also kill a substantial number of lambs.

Control of goats has mainly been by shooting, although killer dogs have been useful in dense bush. Goats have proven to be difficult to poison.

Poisoning pigs, first with arsenic trioxide and later with 1080, in sheep carcasses has been quite successful. A phosphorus and carbon bisulphide mixture and phosphorised pollard were also once used. Pig hunting occurs both as a sport as well as a control measure (MacKintosh, 1950, Shennan, 1960).

SUMMARY

New Zealand has experienced some acute problems as a result of introducing so many species of mammals. Current control methods are quite well developed, but even better organization and methodology are still required to provide additional relief from a number of the problem vertebrates. The problems and the methods of control are described briefly.

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