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Authors: Sutherland, Oliver R.W., Cowan, Phil E., and Orwin, Joanna

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# Biological control of possums *Trichosurus vulpecula* and rabbits *Oryctolagus cuniculus* in New Zealand

**Oliver R.W. Sutherland, Phil E. Cowan & Joanna Orwin**

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Conventional control of two of New Zealand's principal vertebrate pests, the brushtail possum *Trichosurus vulpecula* and the European rabbit *Oryctolagus cuniculus* may not be sustainable on economic or social grounds. Biological control through the deliberate release of debilitating pathogens or vectored fertility control offers a potentially long-term, target-specific and humane option. However, the release of exotic pathogens, possibly genetically modified, into New Zealand raises major social and political concerns on both national and international levels which need to be weighed carefully against economic and conservation gains.

*Key words: biological control, pests, rabbits, possums, fertility control*

*Oliver R.W. Sutherland, Phil E. Cowan & Joanna Orwin, Manaaki Whenua - Landcare Research, and Cooperative Research Centre for Conservation and Management of Marsupials, P.O. Box 69, Lincoln, New Zealand*

Since European colonisation of New Zealand, its environment and economy have suffered major losses from the impact of some introduced plants and animals. The species able to take advantage of either modified or natural environments often rapidly expanded their numbers to pest populations that greatly exceeded the levels reached in their indigenous environments. A principal cause of these population explosions is that the naturally controlling parasites, pathogens, and predators present in their own environments are absent from New Zealand. Artificial control of such vertebrate pests has therefore been imposed by methods which kill, such as trapping, shooting, or poisoning.

At present we rely predominantly on one toxin, sodium monofluoroacetate (1080), to control two of the major vertebrate pests of New Zealand, possums *Trichosurus vulpecula* and European rabbits *Oryctolagus cuniculus*. This toxin has been in use since 1954, with steadily increasing amounts applied each year (4.5 tonnes were applied over 2.5 million ha, i.e. about 8% of NZ's area, in 1995, P. Nelson, pers. comm.). As 1080 is highly toxic, public concern has grown about its widespread use and its possible impact on non-target species, water quality, and general environmental safety. Although there is no evidence of long-term deleterious effects on non-target animals (Spurr 1994), and there is some evidence of benefits to populations of endangered bird species (J. Innes, unpubl. data) and possum-damaged vegetation (Pekelharing & Batcheler 1990) through the use of the chemical, the level of public concern about 1080 prompted a review of possum management by the Parliamentary Commissioner for the Environment (1994). Despite her conclusion that "...the risks of using 1080 are acceptable in relation to the benefits of use", protests continue.

Our current reliance on increasingly unacceptable toxins for managing possum and rabbit populations could be reduced by the use of biological control. Classical biological control aims to reduce pest populations by releasing natural biological control agents throughout the range of the pest. Such agents should be host-specific, self-replicating, humane, environmentally benign, and effective at controlling pest numbers to levels that protect the resource. If such agents do not persist in the environment they may need to be applied regularly against infestations of target pests. Such agents are termed biopesticides. An alternative to biological control based on mortality is control of fertility, which includes strategies such as regulation of lactation and immunocontraception. The potential of fertility control as a practical tool for the management of pest species is gaining wide acceptance from scientists and the public because it is seen as more humane than many current methods.

This paper reviews the potential of such approaches for controlling pest possum and rabbit populations, and discusses the social and political implications of using biological control as a pest management tool.

## Impacts of possums and rabbits

Possums were introduced to New Zealand (total area 270,000 km$^2$) from Australia about 150 years ago to establish a fur trade. They spread rapidly, and an estimated 60 million possums now occupy more than 90% of the country at densities up to 20 times those in their native Australia (Cowan 1990). They threaten both conservation values and agricultural production. They destroy native forests by browsing plants (Cowan 1990, 1991, Nugent 1995); they also compete with native birds for food, disturb their nesting and prey on chicks and eggs (Brown et al. 1993, Innes 1995). Currently about 30% of the land managed by the New Zealand Department of Conservation (78,000 km$^2$) is at risk from possums, but the level of funding allows sustained protection of only about 10% of that area over the next 10 years. Possums also spread bovine tuberculosis (Tb) to cattle and farmed deer. About 23% of New Zealand has possum populations infected with Tb and about 1.8 million hectares are controlled annually for Tb management (Animal Health Board 1995a, P. Livingstone, pers. comm.). Possums already cause NZD 40-60 million of damage and lost production annually. But potential losses in primary production through restrictions on access for meat and dairy products because of the Tb problem could cost New Zealand up to NZD 2,500 million annually (Animal Health Board 1995b). About NZD 48 million is spent annually on possum control and a further NZD 8 million on research (Wright 1995).

Rabbits were first introduced to New Zealand in 1777, with further releases throughout the next century (King 1990). By the 1870s they had become a serious problem. Their subsequent spread across much of New Zealand resulted in overgrazing of native grasslands, permanent degradation of semi-arid regions, and widespread soil erosion in the worst-affected areas (Gibb et al. 1978). At present, rabbits occur on 56% of the total area of New Zealand with an estimated annual cost of NZD 18.4 million to production alone (J.P. Parkes, unpubl. report).

## Biological control for rabbits

### Classical biological control

During the 1870-1880s New Zealand's first biological control programme, against rabbits, was launched with the release of thousands of mustelids, including ferrets *Mustela furo*, stoats *M. erminea* and weasels *M. nivalis vulgaris* (King 1990). But from 1900 onwards, these animals were regarded as pests themselves, as they preyed not only on rabbits but also on a wide range of protected native birds.

At the end of the 1950s, a host-specific rabbit pathogen, the myxoma virus, was released in Australia. It spread rapidly and caused massive mortality (Fenner & Ross 1994). This virus was released in New Zealand at the same time, but as the essential insect vectors were not also introduced, the disease did not establish and the biological control attempt failed. Further proposals to introduce the myxoma virus to New Zealand in 1976, 1987 and 1993 were rejected by the Government after widespread public concern over the inhumaneness of the disease.

In 1984 another host-specific rabbit virus - rabbit calicivirus disease (RCD), earlier known as rabbit haemorrhagic disease - appeared in China (Chasey 1994). This disease spread quickly to Europe in 1986 (Villafuerte et al. 1994) and then to 40 other countries on four continents. In only a few months it killed 64 million farmed rabbits in Italy alone.

Because RCD seemed to have all the desirable characteristics specified for a biological control agent, Australia and New Zealand set up a project in 1989 to evaluate RCD for introduction to both countries. After extensive safety testing established that the disease was specific to the European rabbit, field trials started in quarantine on an Australian off-shore island in March 1995. However, in September 1995 the virus spread accidently to the mainland and since then has killed millions of rabbits in South Australia and New South Wales. Its spread on mainland Australia suggests that RCD may be self-maintaining, and natural vectors, either invertebrate or vertebrate, are suspected of disseminating the disease over vast distances without apparent human intervention. In December 1995 to February 1996 the rate of spread slowed considerably, although a new outbreak 450 km away in Victoria occurred in March 1996. It is not yet known whether the disease will persist, continue to maintain itself, or spread further. To be effective, RCD may need to be manipulated as an applied biopesticide.

In New Zealand, an application to introduce the disease has been urgently developed, in view of the likelihood that RCD will reach New Zealand either accidentally or illegally in the near future. There is uncertainty over RCD's potential persistence and spread in New Zealand. Environmental conditions differ from those in Australia: rabbit densities are lower, rabbits generally do not form warrens in New Zealand as they do in Australia, and nothing is known of possible vectors in New Zealand.

### Fertility control

After resistance to myxomatosis developed in some rabbit populations in Australia, the concept of transmissible (viral-vectored) immunocontraception was pioneered for rabbits and foxes *Vulpes vulpes* by the Cooperative Research Centre for the Biological Control of Vertebrate Pests (Tyndale-Biscoe 1994, 1995). In this approach, a vector is armed with a modified gene that will express a specific antigen, usually a sperm protein. When the vector infects the target pest, it produces copies of the sperm protein, inducing the formation of antibodies against the foreign protein. At mating, sperm is then attacked in the reproductive tract so that fertilisation is blocked. The concept thus depends upon (i) a suitable vector capable of infecting a large proportion of the target population, (ii) a suitable set of target-specific antigens which generate sufficient immunological reactions to block fertilisation and (iii) methods to insert the genes for these target-specific proteins into the vectors and ensure their expression to a sufficient extent in the host.

In Australia, both a suitable vector (a benign myxoma virus) and suitable antigens have been identified for rabbits. For foxes the absence of a suitable vector has shifted the focus to a bait-delivered system. Suitable fox antigens have been identified (Cooperative Research Centre for Biological Control of Vertebrate Pest Populations 1995).

New Zealand will take advantage of the results of this research to help address its rabbit problem.

## Biological control for possums

Biological control has only recently been considered for possums in New Zealand for several reasons. The pest has been recognised as the principal vector of bovine Tb and therefore a major risk to international trade only since the 1980s. Further, a small but periodically lucrative possum fur industry has persisted during this century. Although toxins and traps have been and still are very effective control tools, the current annual cost of conventional control cannot be sustained. For these reasons, research into biological control has been initiated; its implementation is not likely for at least 15 years.

### Classical biological control

In 1993 the New Zealand Government established a research programme to determine whether any parasites or pathogens present in possum populations in Australia were absent in New Zealand populations. Such naturally occurring organisms have the potential to be used as biological control agents or as vectors for the introduction of genetically manipulated material. To date, no classical biological control agent has been discovered, but there are a number of pathogens and nematodes which might play a role as vectors in fertility control of possums.

### Fertility control

At the same time, biological control through fertility regulation was recognised as a national priority research topic (Wright 1992). Almost all current research on fertility regulation of possums focuses on developing immunological blocks to lactation or reproduction - contraception for possums. Other methods with similar consequences involve inhibiting sexual development of young so that they are born sterile, or altering the sex ratio so that only male offspring are produced.

#### Lactation

Possums, like most marsupials, have a short pregnancy (17 days) but a long lactation period (180-200 days). The pouch young is totally dependent on mother's milk for about four months after birth. In response to the physiological development of the young during this time, the milk changes in composition. A biological control agent may therefore be used to interrupt these changes so that the milk does not provide the appropriate nutrients, or more directly, an agent could be used to disrupt lactation so the pouch young dies. This is a natural method of population regulation in marsupials: in the wild when conditions are unfavourable lactation ceases and pouch young die. In some years up to 50% of possum pouch young may die in this way (M.G. Efford, pers. comm.). Milk could also be used as a vehicle for introducing antigens or antibodies into the pouch young to retard their growth, increase mortality, or induce sterility.

#### Hormonal control of reproduction

Another potential target is the brain hormone, gonadotrophin-releasing hormone (GnRH), which is critical to the overall control of reproduction. Recent research on captive possums indicates that targeting this hormone does not alter social behaviour (Jolly et al. 1996), an essential requirement as changing the status of subordinate animals could allow them to be more successful and breed at a greater rate. A possible disadvantage is that because the chemical structure of GnRH is the same in all animals and birds, an agent targeting this hormone would not be species-specific.

#### Sperm, eggs and embryos

Sperm, eggs and embryos are perhaps the most direct targets for fertility control. This option is attracting most research effort in New Zealand for possums, as it is in Australia for rabbits and foxes. In particular, sperm surface proteins and egg-coat zona pellucida proteins are being identified with potential as immunocontraceptive antigens. In a preliminary experiment, 80% of females vaccinated with a crude sperm vaccine were rendered infertile (Duckworth & Buddle 1994).

### Feasibility studies

At the same time, the feasibility of fertility regulation is being assessed. Computer modelling shows that the levels of population suppression necessary to reduce possum densities below target densities for both tuberculosis management and conservation benefits can be achieved under certain assumptions: (i) females need to be targeted rather than males; (ii) a high level of sterilisation (>70%) will be needed to achieve population suppression (Barlow 1991, 1994).

A large-scale field experiment is evaluating the model predictions of the proportion of females that need to be sterilised to reduce wild populations to the desired levels. The experiment will also provide information on effects on social organisation and behaviour, compensatory breeding, and changes in survival rates that could counteract the effects of fertility regulation.

## Social and political issues in biological control

Successful biological control brings about irreversible change in the environment. When that control strategy is based upon the deliberate and widespread release of exotic, possibly genetically modified, vertebrate pathogens, major social and political forces come into play (see Fitzgerald et al. 1996a,b). In particular, the safety of human and other non-target vertebrate species becomes of paramount importance, along with the humaneness of the control strategy. Critical, too, is the impact of the strategy on the values of indigenous people and the obligation of Governments to take these into account. In Australia, rabbits have become an important food for some rural aboriginal communities and in New Zealand, Māori demand involvement in decisions affecting native flora and fauna including the release of exotic organisms into the environment. Public pressure, which may have provided the initial driving force for biological control being considered, may be raised against it. Any concerns about this approach to pest management must therefore be evaluated both before commitment is made to a long-term, costly biological control research and release programme and at key points during its implementation.

Table 1. Acceptability of rabbit killing methods (adapted from Fitzgerald et al. 1996a).

| Method | Percentage of respondents answering | |
|---|---|---|
| | Very unacceptable | Very acceptable |
| Trapping | 13 | 55 |
| Shooting | 4 | 72 |
| Aerial 1080 | 36 | 23 |
| Imported specific virus | 29 | 25 |
| Genetically modified organism | 23 | 33 |

Table 2. Acceptability of specific possum biological control methods (adapted from Fitzgerald et al. 1996b).

| Method | Percentage of respondents answering | |
|---|---|---|
| | Very Unacceptable | Very acceptable |
| Stops possum breeding | 5 | 73 |
| Kills young in pouch | 21 | 35 |
| Increases susceptibility to natural diseases | 23 | 29 |

In a recent survey of attitudes to the control of vertebrate pests in New Zealand, the introduction of RCD for control of rabbits was supported by 51% of the respondents, with 24% rejecting the introduction (Fitzgerald et al. 1996a). But when a range of possible control options were presented the picture was less clear (Table 1). With the introduction of RCD to New Zealand now inevitable, public concerns are focusing particularly on the target-specificity (host range) of the virus, with particular concern for the safety of the kiwi. The potential for the virus to mutate and widen its host range is a further concern as are the economic and social impacts of the release of RCD on farmed and domestic rabbits, respectively. The humaneness of the virus has not been an issue.

In a parallel survey, attitudes to possum management options were canvassed (Fitzgerald et al. 1996b). Prevention of breeding was the most acceptable of various methods of biological control suggested (Table 2), a preference also stated by animal welfare groups in New Zealand (Loague 1993). Safety, humaneness, transmissibility, and specificity were all seen as key issues (Table 3).

Beyond the social and political concerns to be addressed within New Zealand, the development of classical biological control and vectored fertility control have international implications. The release, accidental or de-

Table 3. Importance of safeguards for possum biological control (adapted from Fitzgerald et al. 1996b)

| Safeguard | Percentage of rated responses | |
|---|---|---|
| | Unimportant | Essential |
| Does not affect other animals | 1 | 88 |
| Does not require another organism to spread it | 6 | 62 |
| Is humane | 8 | 70 |
| Is unable to spread outside New Zealand | 4 | 81 |
| Does not affect humans | <1 | 97 |

liberate, of RCD in Australia made its introduction to New Zealand inevitable because of prevailing wind, trade and travel patterns between the two countries. Fertility control raises the question of risk to the target species or related species in the countries where they are indigenous. If a transmissible vector is used, control of possums in New Zealand must not pose an unacceptable risk for possums or other marsupials in Australia or America. These concerns can be addressed by (i) assessment of the probabilities of escape of the biological control agent or vector from New Zealand and methods to prevent it; (ii) assessment of the likelihood of establishment in another country; (iii) development of contingency plans to eradicate any outbreak. The risk of establishment of a vector in another country will depend critically on its ability to compete with existing strains of the same or related organisms. Evidence from studies of the myxoma virus in Australia suggests that competition with existing strains poses a severe barrier to introduction and transmission of new strains (Tyndale-Biscoe 1995). Accidental or illegal releases are therefore likely to have low probability of establishment, although this will need to be established experimentally once suitable vectors have been identified.

## Conclusion

Biological control could offer target-specific, safe, potentially long-term and, cost-effective options for the reduction of pest populations of rabbits and possums in New Zealand. The approach offers relief from the unsustainable economic costs of conventional control techniques. Despite its potential, the use of biological control raises new public anxiety, as shown by the debate over the introduction of myxomatosis and rabbit calicivirus disease to New Zealand. National concerns for the impact on physical and spiritual values of indigenous people and international concerns over potential accidental releases further sharpen the debate. However, if the risks can be demonstrated to be acceptable at national and international levels, the potential benefits to the New Zealand economy and to maintaining New Zealand's contribution to global biodiversity would be enormous.

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