BIOLOGICAL ASPECTS OF RABBIT CONTROL BY MYXOMATOSIS

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Discussion Paper

Centre for Resource Management
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Over recent months and years, numerous reports and submissions have evaluated the suggestion that myxomatosis be re-introduced for rabbit control in New Zealand. Unfortunately, many of these papers make only a very limited use of the myxomatosis story in Britain and Australia. Some are based on no more than a handful of scientific papers, where the available scientific literature is many times larger and more comprehensive. Others assume that because the New Zealand situation is different from elsewhere (and it is), few if any predictions can be made on the likely effectiveness of myxomatosis. Still others tend to be selective in translating the rather complex overseas experience to New Zealand conditions.

This paper presents a synthesis of salient biological information on the rabbit in its New Zealand environment, on the disease virus, and on the flea which would need to be introduced to transmit the virus in the rabbit population. From a reading of more than 50 scientific papers (plus various other published and unpublished articles and reports), and from communications with several scientists directly involved in rabbit research and animal health, the biological constraints and projections of using myxomatosis are re-examined.

The Rabbit Flea *(Spilopsyllus cuniculi)*

The reviewed literature clearly supports the following predictions:

1.1 once established, flea numbers per rabbit would range from 1 or 2 to tens and possibly hundreds.

1.2 a 'flea-load' of about 20-50 fleas per rabbit would be the expected minimum before an effective myxomatosis outbreak could start.

1.3 virtually all rabbits in a local population would need to be infested at or above the minimum 20-50 before such a myxomatosis outbreak could occur, except possibly at low temperatures.

1.4 a flea life cycle of 30 days (range 21-50+) could be expected during the rabbit breeding season, but flea population build-up would slow down with the approach of hot dry weather, and it would effectively cease when the rabbits' main breeding season closed as flea reproduction is intimately linked to the hormonal cycle of the pregnant doe.

1.5 while it has been observed that fleas from different sources may differ in some characteristics (for example, in high temperature tolerance), there have been no attempts to select strains and to thereby afford New Zealand an intelligent choice.

1.6 the flea would not breed on any other animal except the rabbit (there has been no proof of breeding on hares), but small numbers could be expected on hares, plus occasional fleas on cats (especially feral), on ferrets, stoats and weasels,and rarely on man.

The Virus (Myxoma)

The reviewed literature makes it clear that:

2.1 the myxoma virus is host-specific to the rabbit with only one reputed exception - in rare and isolated instances, it has been diagnosed from hares which have become reservoir hosts (but with high resistance) following the myxomatosis crash in rabbit numbers.

2.2 the virus is transmitted by direct contact between rabbits or with residual virus particles in the habitat, or by mechanical transfer by the flea (that is, the virus does not multiply within the flea but adheres to the body surface as a contaminant).

2.3 the virus in a new host rabbit does not become a source of infection for some days (and therefore cannot be immediately spread to other rabbits) and its ability to infect decreases with time away from the host, so that a minimum delay in transmission time between rabbits is an advantage.

2.4 given a minimum delay in transmission time, only a small percentage of fleas transferring between rabbits are likely to be successful in transmitting the virus, and therefore frequent flea transfers appear necessary to promote a speedy myxomatosis outbreak.

2.5 the symptoms of myxomatosis include swelling and closure of the eyes, swelling of ear bases and ano-genital regions, body surface lesions and copious viral discharge.

2.6 although European rabbit populations without previous exposure to the myxoma virus are highly susceptible, the survivors and their subsequent generations are not all equally susceptible to the virus.

2.7 susceptibility will vary with the history of exposure (rabbits surviving viral infection become immune), with maternal immunity (the immune doe confers her immunity on the litter up until they reach 1-2 months old),with

ambient temperatures, with rabbit age and stress, and with strain of virus.

2.8 there are many different strains of the virus, with rabbit knockdown times ranging from 8 days to about 3 weeks, but virulent strains tend quickly to become less virulent in the field (within one season), and in the long term of several years, genetic resistance to a particular strain may build up.

The Rabbit-Virus-Flea dynamics

The environment and population dynamics of the European rabbit *(Oryctolagus cuniculus* (L)) in New Zealand are not only variable from locality to locality, but they are different from all other places where myxomatosis outbreaks have been documented. Although extrapolation to the New Zealand situation is therefore not easy, the available literature does provide strong pointers to the likely limitations of myxomatosis effectiveness in New Zealand as follows:

3.1 the failure of 29 releases of myxoma virus throughout New Zealand in 1951-3 (without the flea) demonstrated that potential virus vectors (New Zealand mosquitoes, sandflies mites, and others) are ineffective in sustaining myxomatosis, at least by themselves.

3.2 as fleas do not fly, and so do not travel long distances, the popular image of a dramatic and wide-spread outbreak of myxomatosis from a few releases as happened in Australia where mosquitoes were primarily responsible, cannot happen naturally in New Zealand (unless rabbits reach plague densities and spread the virus by direct contact).

3.3 to compensate for lack of flying insects, a New Zealand outbreak comparable to the outbreaks in Britain and Australia (although highly improbable because of patchy rabbit distributions and abundance) could only be given a chance by saturation releases of flea and of virus throughout all rabbit country.

3.4 flea releases at 1½-2 kilometre centres across a grid system would require a minimum time-lag of 3-4 years for sufficient dispersal and increase in numbers to effect a myxomatosis outbreak after the virus was released.

Accepting that classic myxomatosis outbreaks are non-repeatable on a vast scale for the New Zealand situation, where the logistics of grid-releases could be prohibitive on account of technology as well as costing, there still remain limitations to myxomatosis effectiveness in local areas:

3.5 low rabbit numbers throughout much of New Zealand would not favour a very significant local build up of myxomatosis, and introduction of the myxoma virus could even be counter-productive by collapsing in turn the population of effective predators (including feral cats, stoats, ferrets), so that rabbit numbers rebounded and increased above present levels.

3.6 the localities with rabbit numbers more amenable to myxomatosis manipulation include pockets of land in the Taranaki Bight, in the Central Plateau, and in some Hawkes Bay and Wairarapa areas, and notably in 14,000-35,000 square kilometres of Marlborough, inland Canterbury and Central Otago.

3.7 as the rabbit is an opportunistic breeder, the duration of the rabbit breeding season is strongly related to the availability of green pasture and varies markedly between years in areas subject to limiting summer drought, such as Marlborough and Central Otago.

3.8 with relatively cold winters (at least in Central Otago), and spring-summer pasture production frequently limited to 2-4 months, the rabbit flea in many years will at best be able to complete 3-4 generations before rabbit breeding drops off, and overseas evidence points to failures in myxomatosis control in fore-shortened seasons.

3.9 on account of reduced flea numbers in most (if not all) winters, plus the delay in myxomatosis outbreaks until flea numbers have risen sufficiently, even a virus outbreak year in Marlborough and Central Otago would not prevent the impact of rabbit damage in spring before myxomatosis took toll.

3.10 these projections imply that myxomatosis would be least effective in the drought years when rabbit increase and damage were at their worst, and that the most vital control is the reduction (by means other than the virus) of overwintering rabbit numbers to limit their increase in spring.

3.11 throughout all rabbit-infested areas of New Zealand, the flea could no doubt sustain a low level of myxomatosis, if not achieve outbreaks, but such marginal benefits of themselves scarcely justify introduction of the virus, and in places the 'benefit' may be negative (see section 3.5).

3.12 the virulence of the released virus strain will also be quickly weakened in the field, such that with time it will become less effective and within a few years a gradual increase in rabbit numbers could be expected, unless periodically manipulated by new virus strains.

3.13 given that the initial flea and virus releases were in only some localities, the ultimate spread of the virus throughout the rabbit population of New Zealand could not be prevented, although in some habitats it might not persist indefinitely.

3.14 given that current reports of some rabbits changing from subterranean to surface dwelling or rock dwelling behaviour were proven (no firm evidence has been sighted by the author), the effect would almost certainly be a further lessening of myxomatosis control potential through reduced habitat suitability for flea survival, especially in the immature stages.

Release Procedures

Procedural details are not appropriate to this report, but should myxomatosis be re-introduced, several biological considerations are noted:

4.1 only a controlled release procedure should be undertaken, where scientific monitoring is an integral part of observing the performance and of learning how to best manage myxomatosis in New Zealand, for there are high risks of immediate and permanent failure with uncontrolled (or illegal) releases (see for example sections 2.7, 2.8).

4.2 flea populations should be well established in the rabbit population before introduction of the virus to obtain maximum initial effectiveness.

4.3 flea stocks will need to comply with strict quarantine requirements and be from sources guaranteed free of foot-and-mouth virus, a general precaution observed for flea introductions to Australia (see also section 5.5).

4.4 a single introduction of fleas (and multiplication in New Zealand rabbit houses) is able to be better monitored for quarantine requirements than would multiple flea introductions were New Zealand to rely on an Australian laboratory to rear and supply all fleas for widespread releases.

4.5 the choice of virus strain (or strains) for release is a matter of some debate, but given that maximum initial effectiveness is the most critical objective, a moderately virulent strain would achieve optimum rates of flea transmission and rabbit kill and so would appear more promising for the initial release than highly virulent or weakly virulent strains.

4.6 if there was a need for subsequent virus releases in a controlled boosting or other manipulation of myxomatosis effectiveness, the choice of strain (or strains) would be dependent on monitoring information (section 4.1).

Animal Health

Linkages between the rabbit, the rabbit flea, myxoma virus and domestic or other animals are an inescapable responsibility of any enquiry concerning the deliberate introduction of new organisms into New Zealand. The reviewed literature suggests that:

5.1 the host specificity of the rabbit flea and myxoma virus give little direct cause for concern, except for the capability of the flea to transfer occasionally to other animals, though not to breed on them (section 1.6).

5.2 an indirect cause for concern and ultra-caution exists, however, in an oblique relationship between the rabbit and the foot-and-mouth virus, for this virus will not only survive in rabbits but has remained pathogenic to cattle after more than one hundred transfers between young rabbits during clinical studies.

5.3 although no reference has yet been located to implicate rabbits as a carrier of foot-and-mouth virus in the field, 28 percent of 540 foot-and-mouth outbreaks were unexplained in Britain in the period 1938-54 when rabbit numbers were high and the rabbit flea was present; and it is further known that non-hosts of foot-and-mouth virus (for example, hedgehogs) can transmit this virus to and from livestock.

5.4 the foot-and-mouth virus is absent from Australia and therefore the Australian experience with rabbits is no argument against their potential to become a carrier.

5.5 it follows that introduction of the rabbit flea into New Zealand presents an extremely unlikely but highly threatening possibility - without the flea in New Zealand, any rabbit that became infected with foot-and-mouth during an outbreak would almost certainly die within the area of slaughtered livestock and become a negligible risk as a carrier; in contrast, in the presence of the flea, the foot-and-mouth virus could potentially be flea-transmitted between rabbits to escape the slaughtered area, and thereby to also escape all further control efforts by eradication.

Clearly, a full evaluation should be made of the rabbit flea as both a known carrier and as a potential carrier of animal diseases in general.

CONCLUSIONS

This paper summarises the evidence of the reviewed literature and cannot include details of the evidence itself, although a selected bibliography is appended. The more important conclusions are as follows:

6.1 the popular image and optimistic prediction of a widespread massive collapse of current rabbit numbers in New Zealand with the introduction of myxomatosis is not supported by documented details of the introductions to Britain, Australia, Macquarie Island and Terra del Fuego.

6.2 the biological requirements to achieve maximum effectiveness in New Zealand by a programme of saturation releases (sections 3.3, 3.4) and monitoring (sections 4.1, 4.6) would therefore be much more demanding in terms of time, manpower, equipment and costing, so that myxomatosis cannot necessarily be promoted as an option that would reduce current fiscal expenditure in rabbit control.

6.3 the immediate benefits of myxomatosis are in the future (by at least 4-5 years to allow for flea culture and establishment), and the initial successes will be short-lived because rabbit numbers

a) will rebound to at least moderate densities during seasonal peaks, and

b) they will continue to vary sufficiently between seasons and localities to require additional control measures, and

c) they will probably remain a major problem during drought years.

6.4 the longer-term benefits of some patchy but moderate control of rabbit numbers by myxomatosis appear difficult to justify (from a biological standpoint) in view of:

a) the need to sustain other rabbit-control measures at a significant level to complement myxomatosis

b) the marginal advantage of patchy and moderate control at a cost of side-effects among non-target animals, including domestic animals and successful predators of the rabbit

c) the remote but highly significant agricultural risk of setting up conditions for foot-and-mouth virus to gain hold in New Zealand.

6.5 the European rabbit in New Zealand has the reputation of being uniquely free of myxomatosis - could that biological advantage allow it to become a more marketable resource in the future?

Appended Note

This discussion paper has evaluated the re-introduction of myxomatosis from only a biological perspective. It has not considered other important perspectives such as:

a) the economic costs and benefits of rabbit control by myxomatosis.

b) strategies for rabbit control during the period of flea establishment and myxomatosis re-introduction (at least 4-5 years).

c) the social and employment implications of a successful or unsuccessful establishment of myxomatosis.

d) the implications of myxomatosis for institutions that are responsible for the control of rabbit numbers.

e) the implications of myxomatosis for a domestic rabbit industry and for recreational hunting.

f) the implications of myxomatosis for future marketing of New Zealand meats.

SELECTED BIBLIOGRAPHY

ANON 1954: Vet. Rec. 66: 483-486. Report of the Departmental Committee on Foot-and-Mouth disease.

ANON 1980: Unpublished M.A.F. internal report, 6pp. Factors associated with the possible introduction of myxomatosis into New Zealand.

ANON 1982: Aspect 7:1. No simple answer to rabbit problem

BELL, J. 1972: Unpublished M.A.F. Overseas Travel Report on a visit to Canberra to attend the second myxomatosis conference.

BELL, J. et al., 1980: M.A.F. special publication, Research News 4: 1-2. Rabbit Research Group, P.O. Box 31-011, Christchurch.

BROTHERS, N.P., EBERHARD, I.E., COPSON, G.R., and SKIRA, I.J. 1982: Aust. Wildlife Res. 9: 477-83. Control of rabbits on Macquarie Island by myxomatosis.

BULL, P.C. 1953: N.Z. J. Sci. Tech. (B) 34: 341-72. Parasites of the wild rabbit, Oryctolagus cuniculus (L.) in New Zealand.

CUNHA, R.G., EICHHORN, E.A. 1959: Amer. Jn. Vet. Res. 20: 733-7 Studies on rabbit-adapted foot-and-mouth disease virus. I. Propogation and Pathogenicity.

FILMER, J.F. 1953: N.Z. J. Agric. 87: 402-4. Disappointing tests of myxomatosis as rabbit control.

GIBB, J.A. 1976? Unpublished Report compiled for the Technical Advisory Committee (Animal Pests). The Introduction of myxomatosis to control rabbits in N.Z.

GIBB, J.A. and FLUX, J.E.C. in press. Search 14: Why New Zealand should not use myxomatosis in rabbit control operations.

GIBB, J.A., WARD, C.P. and WARD, G.D., 1978: N.Z. D.S.I.R. Bull. 223. 89pp. Natural control of a population of rabbits, Oryctolagus cuniculus (L.) for 10 years in the Kourarau enclosure.

GIBB, J.A., WARD, G.D. and WARD, C.P. 1969: N.Z. J. Sci. 12: 509-34. An experiment in the control of a sparse population of wild rabbits (Oryctolagus cuniculus L.)

JOHNSTON, G.C. 1973: Tasmanian J. Agric. 44: 157-8. The European Rabbit flea in Tasmania.

MARSHALL, I.E. 1959: J. Hyg., Camb. 57: 484-97. The influence of ambient temperatures on the course of myxomatosis in rabbits.

MEAD-BRIGGS, A.R. 1977: Appl. Biol. 2: 183-261. The European Rabbit, the European Rabbit Flea and myxomatosis.

MEAD-BRIGGS, A.R., VAUGHAN, J.A. and RENNISON, B.D. 1975: Parasitology 70: 103-118. Seasonal variation in numbers of the rabbit flea on the wild rabbit.

MILES, J.A.R. 1982: Unpublished manuscript. Myxomatosis. (Published report, Otago Daily Times, 6 Oct. 1982).

RADCLIFFE, J.E. 1979: Unpublished Ph.D. thesis, Lincoln College, University of Canterbury, N.Z. Climatic and aspect influences on pasture production in New Zealand.

ROSS, J. and SANDERS, M.F. 1977: J. Hyg. Camb. 79: 411-5. Innate resistance to myxomatosis in wild rabbits in England.

ROTHSCHILD, M. and FORD, B., 1965: Proc. R. Ent. Soc. Lond. (A) General. 40: 109-117. Observations on gravid rabbit fleas (Spilopsyllus cuniculi (Dale)) parasitising the hare Lepus europaeus Pallas), together with further speculations concerning the course of myxomatosis at Ashton, Northants.

ROTHSCHILD, M., FORD, B.,and HUGHES, M., 1970: Transactions Zoological Society London 32 (2) 107-188 + 13 plates. Maturation of the male rabbit flea (Spilopsyllus cuniculi) and the oriental rat flea (Xenopsylla cheopis): some effects of mammalian hormones on development and impregnation.

SHEPHERD, R.C.H. and EDMONDS, J.W. 1976: Australian Wildlife Res. 3: 29-44. The establishment and spread of Spilopsyllus cuniculi (Dale) and its location on the host, Oryctolagus cuniculus (L.) in the Mallee region of Victoria.

SHEPHERD, R.C.H. and EDMONDS, J.W. 1977. J. Hyg. Camb. 79: 405-9. Myxomatosis: the transmission of a highly virulent strain of myxoma virus by the European rabbit flea Spilopsyllus cuniculi (Dale) in the Mallee region of Victoria

SHEPHERD, R.C.H. and EDMONDS, J.W. 1978: J. Hyg. Camb. 81: 399-403. Myxomatosis: changes in the epidemiology of myxomatosis coincident with the establishment of the European rabbit flea Spilopsyllus cuniculi (Dale in the Mallee region of Victoria.

SHEPHERD, R.C.H. and EDMONDS, J.W. 1979: J. Hyg. Camb. 83: 285-94. Myxomatosis: the release and spread of the European rabbit flea Spilopsyllus cuniculi (Dale) in the Central District of Victoria.

SHEPHERD, R.C.H. and EDMONDS, J.W. 1980: J. Hyg. Camb. 84: 109-113. Myxomatosis: the emergence of male and female European rabbit fleas Spilopsyllus cuniculi (Dale) from laboratory studies.

SOBEY, W.R. and MENZIES, W. 1969: Aust. J. Science 31: 404-6. Myxomatosis: The introduction of the European Rabbit Flea Spilopsyllus cuniculi (Dale) into Australia.

THOMPSON, H.V. and WORDEN, A.N. 1956: "The Rabbit", 240pp. Collins.

TRAUB, R. and STARCKE, H. (Eds). 1980: "Fleas", 420pp. Proceedings of the International Conference on Fleas, Ashton Wold/Peterborough/UK 21-25 June 1977, A.A. Balkema/Rotterdam.

WATSON, J.S. 1957: N.Z. J. Sci. Tech. 38(B): 451-82. Reproduction of the wild rabbit, Oryctolagus cuniculus (L.) in Hawke's Bay, New Zealand.

WILLIAMS, J.M. 1978: Unpublished M.A.F. Overseas Travel Report on the Australian Vertebrate Pest Control Conference and on Rabbit Research and control groups in New South Wales, A.C.T., Victoria, South Australia and West Australia.

WODZICKI, K.A. and DARWIN, J.H. 1962: N.Z. J. Sci. 5: 463-74. Observations on the reproduction of the wild rabbit (Oryctolagus cuniculus (L.) at varying latitudes in New Zealand.

WOOD, D.H. 1980: J. Anim. Ecol. 49: 55-79. The demography of a rabbit population in an arid region of New South Wales, Australia.