

Control and eradication of animal diseases in New Zealand

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Abstract

New Zealand is free from all the major epidemic (Office International des Épizooties List A) diseases of animals and other important diseases, such as rabies and the transmissible spongiform encephalopathies. The once endemic conditions of sheep scab (*Psoroptes ovis*), bovine brucellosis (*Brucella abortus*), hydatids (*Echinococcus granulosus*) and Aujeszky's disease have been eradicated. Anthrax (*Bacillus anthracis*) is no longer considered endemic and Pullorum disease (*Salmonella Pullorum*) has effectively been eradicated from commercial poultry flocks. There are current control programmes for bovine tuberculosis (*Mycobacterium bovis*), enzootic bovine leucosis in dairy cattle, infectious bursal disease, ovine epididymitis (*Brucella ovis*), and caprine arthritis encephalitis. Historically, incursions by three important non-endemic diseases, contagious bovine pleuropneumonia, classical swine fever and scrapie, have been successfully eliminated. Any new occurrence of a serious exotic disease would be dealt with swiftly using powerful legislative authorities available for the purpose.

Introduction

New Zealand has a thriving pastoral industry that is a significant contributor to the nation's income from international trade and the pig and poultry industries are important to the internal economy. Major factors in the success of the industries are the freedom from serious epidemic diseases and the control or eradication of once endemic infectious and parasitic diseases of economic or public health importance.

Before the coming of mankind to the land mass that is now New Zealand, there were only two indigenous species of mammals, both bats. All other mammals were brought here by human agency. The original animals whose descendants now form the animal industries were introduced from Europe, particularly Britain, either directly or indirectly from Australia.

Probably because of the slow voyage times of sailing ships, most animals that might have been affected by serious epidemic viral diseases had either died or ceased to be infective before landing in New Zealand. Chronic infectious diseases and parasitic infestations however persisted and 19th-century herds and flocks were affected with them. Sheep scab was a scourge of the early sheep flocks, tuberculosis and bovine brucellosis in cattle herds caused significant concern from the 1890s onwards, and hydatids became a serious public health problem in the 20th century.

There was good fortune too. Contagious bovine pleuropneumonia never became established in the national cattle industry despite the high risk of importing this disease with cattle from both Australia and Britain in the 19th century. Scrapie was not introduced until after more than a century of sheep importations and rabies was not introduced with imported carnivores, despite its sometimes-long incubation period.

In the 19th century there developed an understanding of the need for active prevention of disease introduction, probably due to recognition of the damage done to the European and British cattle industries by contagious bovine pleuropneumonia and the epi-

demics of foot-and-mouth disease and Rinderpest in the 1860s. The Diseased Cattle Act of 1861 was an early statute that had as its purpose the quarantine of imported cattle and the control of contagious bovine pleuropneumonia and other infectious diseases of cattle. It was succeeded and supplemented by other legislation that eventually embraced all livestock and unfarmed and non-mammalian animals, and addressed a range of important diseases. The modern day statute (the Biosecurity Act 1993) provides for a rational system of measures to prevent introduction of disease, for surveillance and for the management of introduced or endemic diseases. Though many powers in this Act echo those from previous legislation, it contains the important and novel concept of allowing for the use of those powers by agencies, other than government, to control or eradicate disease.

The measures adopted since the latter part of the 19th century to guard against the introduction of disease have had their failures. Anthrax, contagious bovine pleuropneumonia, classical swine fever, scrapie and Aujeszky's disease have all been introduced at some time but all have been successfully eradicated.

It is the purpose of this review to record the actions taken to eradicate the occasional incursions of exotic diseases that have threatened our livestock industries, and to chronicle the campaigns in New Zealand against the major endemic diseases of livestock in this country.

Strategies, tactics and authorities

The methods used to eradicate animal diseases exemplify a range of disease control strategies such as "stamping out" affected herds and flocks, compulsory treatment, vaccination, and test and removal. In some programmes, elements of more than one strategy were used. Tactics such as quarantine of animals or farms and movement restrictions in geographical areas were used, at some stage at least, in all official eradication efforts.

Surveillance, either passive or active, has been an underlying feature of most programmes. In particular, the slaughterhouses that process meat animals have been used to source data on many endemic diseases. Disease control and eradication programmes have evolved considerably over the years as understanding of epidemiological factors, diagnostic methods and surveillance capabilities have improved and been utilised.

Until the latter part of the 20th century all eradication programmes were carried out under the aegis of the government and using the authority of legislation. All were mandatory, though some had voluntary phases in their early stages. The current Biosecurity Act permits non-governmental agencies, e.g. animal industry groups, to use powers of the Act for disease control programmes they wish to pursue. There are also examples of voluntary disease control programmes that do not depend on legislation in any way.

The infectious and parasitic diseases that have been eradicated or are subject to control programmes are discussed under the basic type of strategy used.

BSE	Bovine spongiform encephalopathy
CFT	Complement fixation test
EBL	Enzootic bovine leucosis
ELISA	Enzyme-linked immunosorbent assay
PPD	Purified protein derivative

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Stamping out

This method involves the quarantine of affected farms or areas and the destruction of infected and in-contact animals.

Contagious bovine pleuropneumonia

Despite the uncontrolled nature of early cattle importations into this country, contagious bovine pleuropneumonia never became established in the national cattle herd. Although the Diseased Cattle Act of 1861 was principally directed at this disease, it was recognised, given the inability at that time to diagnose the disease in its preclinical phase, that inspection of cattle at the port of entry could not detect carrier animals. However, commercial pressures prevented a ban on importation of cattle. Eventually and inevitably, this disease was introduced with cattle imported in 1880 from New South Wales, Australia. Two herds were affected. The disease was successfully eradicated using a stamping out policy (Laing 1964) and has not recurred since.

Classical swine fever

A disease that was diagnosed as swine fever was reported in Otago in the summer of 1894–95 (Anonymous 1895). A stamping out policy was adopted. Between then and 1903 there were numerous occurrences of what was believed to be swine fever. A very detailed examination of one outbreak in 1899, however, revealed the presence of motile, gram-negative bacilli in various organs, that were believed to be the aetiological agent of swine fever. Apparently causative bacteria were found in many subsequent outbreaks of disease. These bacteria were cultured and produced disease in a number of laboratory animals and experimental pigs (Anonymous 1899, 1903).

No possible means of introduction of swine fever were identified for any of the outbreaks around the turn of the 20th century (Anonymous 1899, 1902). It must be remembered that at that time the viral aetiology of swine fever was not known and the swine fever/swine plague/salmonellosis complex had not been resolved. Certainly, there were no more reports of swine fever in the earlier part of the 20th century after the viral aetiology of the disease was established in 1904. In retrospect, what had been diagnosed as swine fever was almost certainly swine plague (pasteurellosis), or salmonellosis.

Over a 3-month period in 1933, however, 13 herds in the Wellington area were infected with classical swine fever, definitively diagnosed by blood transmission to experimental pigs. In every instance the herds had been fed swill and there was sharing of swill containers. A strong inference was drawn that the virus was introduced by illegally landed ship's garbage containing meat scraps that found its way into the pig feed. All affected and in-contact pigs, totalling 1,920 animals, were destroyed and buried (Anonymous 1934).

A further outbreak of classical swine fever, again associated with the feeding of food scraps, this time from a naval shore base, occurred in 1953 and was dealt with in the same manner. Tracing operations and inspection of all other herds in the same general area revealed that the outbreak had been contained to one herd (Watt and Wallace 1954). Since 1953, New Zealand has remained free from classical swine fever.

Scrapie

The early importations of sheep were Merinos from Australia. There is no evidence that any Australian Merinos were ever affected with scrapie. With the expansion of the sheep industry from predominantly wool-producing enterprises to meat production, several British breeds were imported, some of which form the predominant basis of the present-day national flock. Many thousands of sheep in hundreds of shipments were imported over more than 100 years with no special precautions taken against

the introduction of scrapie but the disease was not introduced (Adlam 1977). This appears to be a matter of very good luck as scrapie is a slow-developing disease and could easily have been introduced unwittingly.

The disease was finally introduced in 1950 in Suffolk sheep imported from Britain. The affected sheep had been born in Britain in 1949, imported to New Zealand in 1950, and the disease became clinically apparent in 1952. When the disease was diagnosed, only the breeding flock of stud Suffolk sheep on the index property and sheep in direct contact with them were destroyed. Other sheep on the property were not slaughtered (Brash 1952). A further outbreak of the disease occurred in 1954 and was traceable to the index case. This secondary case, the original index farm, and all other farms to which any sheep from the two outbreak farms had been taken (a total of 191 properties) were quarantined. All 4,339 sheep on the properties were destroyed and the farms quarantined for 3 years before eradication was declared (Anonymous 1955).

After the experiences of the 1950s, no sheep were imported other than from Australia, until 1972 when animals were again imported from Britain. These were used in a breeding project that had as its ultimate aim improvement in productivity of the national flock. They and their progeny were to be held in prolonged quarantine. Whilst all animals in the project were still in quarantine, scrapie was diagnosed in 1976 and again in 1977. The project was terminated and all the animals involved destroyed (Anonymous 1998).

In light of the bovine spongiform encephalopathy (BSE) epidemic that started in the United Kingdom in the 1980s, active surveillance in cattle has been undertaken and no evidence of this disease has been found. Today, this country is one of a relative handful of countries that are recognised as being free from transmissible spongiform encephalopathies.

Compulsory treatment

Sheep scab

The parasite *Psoroptes ovis* was introduced on sheep imported from Australia in the 1840s and subsequently became endemic in New Zealand. In 1849, legislation to control sheep scab was enacted. All flocks were then subjected to active surveillance by stock inspectors for the presence of the infestation and affected flocks were compulsorily treated. Early treatments were not effective but with the introduction of arsenical dips about 1870 the prevalence of infestation fell steadily. By the early 1880s most flocks in most areas were free from the parasite. However, a serious flare-up of this disease occurred in Marlborough in 1884. Refractory pockets of disease were dealt with by destruction of affected flocks and feral sheep in the area. Remaining infestations in Marlborough and Auckland were finally eradicated (Laing 1964) and the last reported case of sheep scab was found in 1890 (Anonymous 1893). Freedom from sheep scab was officially declared in 1893 (Anonymous 1894), marking the end of a dogged and not always popular campaign.

Hydatids (echinococcosis)

Hydatid disease in this country was recognised in the 19th century. By 1897, hydatids could be found in virtually all mobs of slaughtered stock and up to 80% of dogs were estimated to harbour the tapeworm. Recommendations were made at that time to treat all dogs for the adult worm and to control dog-feeding practices (Anonymous 1897). This was the precise strategy that was eventually used in the organised campaign against the parasite. In the meantime, hydatid disease became one of significant public health concern and together with *Cysticercus tenuicollis* also caused losses to the meat industry. Despite efforts by the medical

and veterinary professions to interest farmers in control of the disease (Thompson 1963), it was not until many years later that a national control programme was instituted. Several local voluntary schemes were established, particularly from 1957, and soon a consensus developed that the treatment of all dogs should become compulsory. It was decided that local authorities should administer such a campaign (Anonymous 1959). This was unusual, as all national disease control programmes up to that time had been executed by central government and probably came about because dog registration was already in the hand of local bodies. A clinching factor in the adoption of a compulsory programme was that *C. tenuicollis* would also be controlled as a collateral benefit (Thompson 1963).

The Hydatids Act of 1959 brought a mandatory programme into effect. In addition to requirements regarding treatment and feeding of dogs, slaughterhouse surveillance was used to identify affected sheep flocks for investigation of dog-feeding practices and the need for additional follow-up treatment of dogs on affected properties. The strategy was supported by continuing education of dog owners about control and feeding of dogs. The campaign was rapidly successful in reducing the incidence of hydatids in humans and livestock. The reduced incidence of echinococcosis and *C. tenuicollis* had the expected benefits in the marketability of offal.

The last discovery of *E. granulosus* cysts in sheep was in 1996, on Arapawa Island in the Marlborough Sounds. Controls were put in place to ensure that there would not be any recrudescence (Pharo and van der Logt 1997). Though cysts have since been found in a very few aged or imported cattle, they are not thought to represent maintenance of the parasite. Cattle are epidemiologically unimportant in the life-cycle in this country, because of the low rate of cyst fertility in cattle, and because cattle offal is less commonly consumed by dogs either by scavenging dead cattle or as the result of home killing.

Hydatids can now be considered almost certainly eradicated, thanks largely to the cooperation of dog owners and the conscientiousness of local authority officers. The Ministry of Agriculture and Forestry (MAF) is currently working towards confirming the complete eradication of *E. granulosus* (Shaw 2001).

Vaccination

Anthrax

Anthrax was introduced by the importation of unsterilised bones or bone-dust from the Indian sub-continent and Australia. Thousands of tonnes of green bones were landed annually and crushed for manure. The application of this bone-manure was followed by outbreaks of anthrax in the areas in which it was used, notably in the Auckland province, Taranaki and Southland (Barry 1954). The first outbreaks were diagnosed in 1895 (Anonymous 1896). This led to restrictions being placed on the importation of bones and bone-dust but initially these were ineffective. Ultimately, in 1905, regulations were introduced under which New Zealand inspectors, located in Australia and India, supervised the proper sterilisation, at source, of material imported here. As at 1905, 41 outbreaks had occurred. Thereafter, outbreaks of the disease declined markedly and most were recrudescences of earlier contamination, though an outbreak in 1944 in Foxton was attributed to imported Indian jute processed at a nearby flax mill (Barry 1954). The supervision of bone-manure sterilisation ceased in 1927 (Anonymous 1928) as mineral fertilisers had superseded bone-based manures. The last outbreaks, which were recrudescences of earlier infections, occurred on two farms in Te Awamutu in 1954 (Anonymous 1954). Altogether, some 52 outbreaks occurred over about 60 years.

The disease came to be regarded as endemic, probably after an outbreak in Dargaville in 1932. A decision was made to permanently quarantine all properties that had outbreaks after that time and to vaccinate stock annually. Presumably the rationale for this was that by preventing clinical disease, further environmental contamination would be eliminated and the organism would eventually die out. That reasoning was probably based on the assumption that *B. anthracis* was an obligate pathogen. The number of vaccinated farms reached a peak of eight after the 1954 incidents.

The vaccination policy was discontinued in the mid-1970s when its rationale came into question. In the light of modern understanding of the ecology of *B. anthracis*, the decline of endemic anthrax in the 20th century may have been more to do with geoclimatic factors that did not support a vegetative phase of the organism, rather than vaccination.

Test and removal

Bovine tuberculosis

During the 1880s, veterinary surgeons drew attention to the occurrence of this disease (Laing 1964). As early as 1895 tuberculin testing of dairy cows supplying town milk was suggested (Anonymous 1895) and the test was used for the first time in that year (Anonymous 1896). Many cattle were tuberculin tested in the late 1890s and there was growing enthusiasm that the disease could be eradicated. However, the practical difficulties (lack of skilled staff) and costs involved, both to the State (cost of compensation for animals condemned) and to farmers (loss of production), precluded such an ambitious undertaking (Anonymous 1899).

With the wisdom of hindsight, it is tempting to speculate that had it been possible to resolutely pursue eradication from the 1890s, the infection of wild animal populations that now constitute reservoirs of infection for livestock might never have come about and the disease could perhaps have been eradicated by now. Instead, for 60 years, official policy was directed at minimisation of the public health risk by removal of clinically affected animals from herds, supplemented by biological testing of composite milk samples (from about 1910 until 1946) and later by mandatory pasteurisation of town milk (from 1946). This is not to say that there were no suggestions for a coordinated scheme emanating from official sources, as was documented, for example, in 1921 and 1938 (Anonymous 1921, 1938).

In the meantime, some individuals and groups of dairy farmers did embark on voluntary herd eradication and by the 1940s tuberculosis was eradicated from an appreciable number of town-supply herds (Laing 1955). In 1945, legislation was enacted to provide for compulsory testing of all town-milk herds (Anonymous 1946) but did not come into general effect until 1956 when more generous compensation was provided by new legislation. An effective, nationally prosecuted, and mandatory test and slaughter programme for the eradication of the disease can be dated from this time.

The test used was the intradermal test administered in the caudal skin fold, using heat-concentrated tuberculin "old tuberculin" produced on synthetic medium. Test-positive animals were slaughtered at meat processing plants, and compensation paid to owners. In individual herds in which non-specific reactivity was suspected, a thermal test was used as a confirmatory test. Later, purified protein derivative (PPD) tuberculins were adopted and the thermal test discarded in favour of the comparative avian-mammalian intradermal PPD test. Lymphocyte proliferation assay and a gamma interferon test are relatively recent additional tests used in the programme.

For more than half a century the major concern had been the public health risk posed by bovine tuberculosis. A new factor, however, came increasingly into the equation in the late 1950s and 1960s, being the quality of beef and dairy products that New Zealand traded on international markets. It became vital that New Zealand embark on a tuberculosis eradication scheme encompassing the entire national herd.

As a first step, the scheme was extended in 1958, on a voluntary basis, to herds supplying milk for manufacturing butter, cheese and other exported dairy products. Compulsory testing of these herds commenced in 1961 and was carried out progressively, on an area basis, starting in the low-prevalence areas of the South Island and working up into the higher prevalence areas in the North Island. All dairy cattle were under regular test by May 1970.

In 1968, testing of beef breeding herds on a voluntary basis was introduced in the whole of the South Island and part of the North Island. In 1970, compulsory testing of remaining beef breeding herds was introduced in the South Island and thereafter progressively extended to the rest of the country, generally in conjunction with testing for brucellosis. All herds were under test by August 1977.

The domestication of wild deer started in the 1970s and deer farming soon became a viable enterprise. It was already known that bovine tuberculosis occurred in some of the wild populations and the disease inevitably was found in domesticated herds. An intradermal PPD test, applied at the cervical site, was developed in the 1978–80 period (PG Livingstone¹, pers. comm.). A structured voluntary scheme to control tuberculosis in deer herds was promoted in 1985 (Anonymous 1986). When the greater proportion of herds had been included within its ambit, the scheme was made mandatory in 1990 (Anonymous 1990).

Expectations of early eradication were frustrated in the late 1960s. Tuberculosis was diagnosed in brushtail possums (*Trichosurus vulpecula*), an introduced pest species (Ekdahl et al 1970). It soon became apparent from epidemiological studies that infected possums were true reservoir hosts for *M. bovis* and transmitted infection to cattle (Davidson 1976; Jackson 2002). Subsequently, infected possum populations were identified in a number of other areas of the country and later it was to be found that farmed deer could also be infected by this reservoir host. From 1972 onwards, major efforts have gone into control of infected possum populations.

Though bovine tuberculosis has not yet been eradicated, the disease in livestock is well under control. A great deal of research, and financial and other resources have been and continue to be directed at overcoming the reservoir host problem. The annual incidence of the disease has been falling over recent years to 0.035% in 2000–2001 (calculated on the assumption that all tuberculin reactors slaughtered were actually infected plus the number of diseased non-reactors detected at commercial slaughter) in a population of some 11 million cattle and deer. The period prevalence of infected herds for the 2000–2001 year is 1.37%. The current management-plan proposal aims for eradication to a period prevalence of less than 0.2% infected herds by 2013 (PG Livingstone, pers. comm.)

Bovine brucellosis

What is now recognised as bovine brucellosis, caused by *B. abortus* was first reported in 1895 (Anonymous 1895). The disease was responsible for massive losses in the early days of the dairy industry and in 1907 it was estimated that the disease caused greater loss to dairy farmers than all other diseases put together

(Anonymous 1907).

In 1941, Strain-19 vaccine was introduced for assessment. Subsequent trials showed it to be very effective in reducing wastage due to abortion and sterility. From 1950 onwards, farmers were actively encouraged to have their calves vaccinated. By 1966, it was estimated that voluntary vaccination rates were 90% and 70%, respectively, in female dairy and beef calves retained for breeding (Adlam, cited by Shepherd et al 1980).

In the mid-1960s it became apparent that New Zealand would have to embark on an eradication policy in order to protect its overseas markets by providing high-quality dairy products and beef.

A slaughterhouse survey of cattle in 1966, using the serum agglutination test, showed that about 15% were seropositive (Adlam 1978). This was probably an overestimate of the true prevalence of infection, as at that time vaccination of adults was not prohibited, resulting in some false-positive test reactions. Nevertheless, it was considered that this was too great a prevalence of sero-positives to make a test and slaughter programme affordable at that time. Instead, it was decided to make vaccination of all calves retained for breeding purposes compulsory, thereby reducing transmission rates and consequently prevalence of the infection (Adlam 1978). At the same time, vaccination of older cattle was prohibited in order to reduce the diagnostic problem caused by adult vaccination. The adoption of this vaccination policy, in 1966, marked the beginning of the campaign to eradicate the disease.

In preparation for the test and slaughter phase of the brucellosis eradication programme, trial work was carried out in 1969–70 to compare the efficacies of various serological tests. It was decided to adopt the complement fixation test (CFT) as the definitive test as it had the best sensitivity and specificity of the tests assessed (Adlam 1978).

An initial voluntary test and slaughter programme commenced, principally in Taranaki, in December 1969. Because of the laborious nature of the CFT, a plate agglutination test was used initially as a screening test, positive sera being subject to the CFT for confirmation. However, the CFT was adapted to automation in 1970 and shown to be as accurate as the manual CFT (Te Punga 1971), enabling it to then be used on all samples.

In 1971, testing was made mandatory in the Taranaki and Waikato districts and in 1972 the government committed itself to national eradication. The management strategy called for all eligible animals (approximately 5 million cattle in 40,000 herds) to be brought under test surveillance within 5 years (Davidson 1978). Testing of sera with the CFT was centralised at one laboratory so that test procedures and interpretation could be standardised. This standardisation was achieved (Elliott et al 1978) and quality control of procedures exercised (Liberona et al 1978).

In addition to the serotesting of herds, farmers were obliged to have all abortions in their herds examined by their veterinarians to provide additional surveillance of disease incidence. When the incidence of abortion due to *B. abortus* became very low, this procedure was discontinued.

In 1975, Strain-19 vaccination of calves ceased to be compulsory, in anticipation of problems due to interference with serological diagnosis in some vaccinates (Adlam 1978), and eventually vaccination was prohibited. It was recognised that the consequent creation of immunologically naïve herds presented a risk of high incidence rates within individual herds if they were reinfected and indeed this happened on a few occasions in the latter part of

¹ PG Livingstone, Animal Health Board, Wellington, New Zealand

the programme. Adult vaccination with a reduced dose of Strain-19 was tried in a few such herds, with somewhat mixed results (Beckett and MacDiarmid 1985, 1987). Other affected herds were totally depopulated.

Throughout the eradication scheme, surveillance of dairy herds accredited free from the disease was maintained by means of the ring agglutination test on bulk milk samples. In accredited beef herds, testing of sera from a randomly selected sample of breeding cattle was practised until the last stages of the programme, when the intradermal brucellin test was substituted for serum testing (MacDiarmid 1991).

The last infected herds were cleared in 1989 (Hellstrom 1991) and New Zealand has been free from the disease since.

Although the principal aim of the scheme had been to ensure continued international marketability of dairy and beef products, collateral gains were realised in cattle productivity and public health. These were not only significant in themselves but were achieved in an economically beneficial way, with the programme yielding an internal rate of return of more than 10% (Shepherd et al 1980).

The eradication of bovine brucellosis over a period of about 23 years was a considerable achievement. Considering the high prevalence of the disease prior to the scheme and the number of cattle involved, it can probably be regarded as the most successful eradication programme in the country's history to date. Its success is a tribute to the foresight of successive governments in underwriting its cost and to the farmers, veterinarians, livestock officers, laboratory personnel and all others involved.

Aujeszky's disease (pseudorabies)

Aujeszky's disease was first diagnosed in New Zealand in 1976 (Anonymous 1976). Following its initial diagnosis a retrospective survey showed that the infection had been present at least 3 years previously (Burgess et al 1976). It is not known when the disease was introduced but it probably came with importations of new breeds of pigs from Britain. Field surveys showed that the infection was confined to herds in the North Island (Durham and O'Hara 1980; O'Hara 1985) and an abattoir survey of pigs from the southern part of the North Island showed 47 herds to be infected (Durham 1987). From 1988, continuous surveillance of herds in the North Island was carried out using serological testing of all culled breeding animals at abattoirs, and on-farm testing of herds within 1 kilometre of known infected herds (MacDiarmid 1990). In all, 54 infected herds were identified in the period 1988–95 (Motha et al 1997). By the time abattoir surveillance concluded in April 1999, 1.4% of animals in 1.3% of herds in the North Island were shown to be infected (Motha 2001).

Known infected herds were quarantined with movement of pigs being permitted only for slaughter. Restrictions were placed on the movement of pigs to the South Island in 1985 to prevent the disease spreading there.

A herd accreditation scheme was introduced in 1986 to provide a source of disease-free replacement pigs for infected herds. This scheme was based on testing breeding stock (using an ELISA test) and removal of infected individuals (MacDiarmid 1987). In 1989, an industry-funded national eradication scheme was launched. The strategy for the programme included test and removal, depopulation and restocking, and vaccination (MacDiarmid 1990). Test and removal was the standard approach taken and was successful in most infected herds. Depopulation was employed in a few, mostly small, herds. Vaccination was successfully used in a small number of herds with high rates of prevalence. Gene-deleted "marker" vaccines were employed so that subsequent serological tests could differentiate between antibodies due to the vaccine

and those caused by field virus (Motha et al 1997).

The last pigs seropositive for the disease were detected in 1995, but to confirm freedom from infection the slaughterhouse surveillance of culled pigs continued until 1999 (MacDiarmid 2000). Aujeszky's disease has now been successfully eradicated.

Epididymitis of sheep (*Brucella ovis*)

What is now recognised as *B. ovis*, first reported in 1950, was associated with abortion and epididymitis in sheep (Anonymous 1951; Ridler 2002). Surveys in the Gisborne, Waikato and Wairarapa districts showed that epididymitis was common in rams (Anonymous 1952). The organism was shown to fulfil Koch's postulates, and given its current generic classification in 1953 (Buddle and Boyes 1953; Simons and Hall 1953). An effective vaccine was first developed in the 1950s, and a CFT was developed for diagnostic purposes (Clapp 1955).

The CFT was adapted for large-scale use (Weddell 1974) and refined to make it very sensitive (Ris 1974). These developments allowed veterinarians to encourage many individual ram breeders to eradicate the infection from their flocks, and a pilot eradication project was set up in the 1970s, administered by the Sheep Breeders Association. From this flowed a national industry-based, voluntary scheme for accrediting *B. ovis*-free flocks, which commenced in 1986 and has involved some 3,000 stud and commercial ram breeding flocks. The scheme provides a source of *B. ovis*-free rams (Reichel and West 1997) but could also provide the basis for an eradication programme in the future.

Caprine arthritis encephalitis

Caprine arthritis encephalitis was first reported in New Zealand in 1982 in commercial goats imported from Australia (Oliver 1982; Oliver et al 1982). Its presence in goat flocks at large was subsequently demonstrated, at a low prevalence, by active surveillance (MacDiarmid 1983).

In response to a request from the goat industry, the government agreed to supervise a voluntary programme aimed at accrediting flocks as free from caprine arthritis encephalitis (MacDiarmid 1984). This quickly resulted in a number of herds reaching accredited status, but interest in the programme has since declined as owners saw little financial benefit. Nevertheless, the scheme provides a basis for eradication.

Enzootic bovine leucosis

Enzootic bovine leucosis (EBL) in dairy cattle is subject to a voluntary eradication programme implemented in 1996, which is funded and operated by the dairy industry. The programme is based on the testing of bulk and individual milk samples to establish the EBL status of herds and individual animals within herds, respectively, and culling of EBL-positive animals (Hayes and Burton 1998). As all dairy manufacturing companies require their suppliers to join the scheme, all dairy herds will be included within the scheme by May 2002 and all test-positive animals are to be culled no later than 2003. Eradication from all dairy herds is projected by 2004 (Hayes and Burton 2001).

Avian diseases

Control of Pullorum disease, by test and removal, was taken up on a voluntary basis by all commercial poultry hatcheries as they developed along modern lines. The disease now appears to be eradicated from commercial flocks, as the last isolation of *Salmonella* Pullorum was in 1985 (Black 1997).

A low-virulence strain of infectious bursal disease virus was discovered in 1993. An industry-managed programme, using a test and removal strategy, was implemented in 1994. By 1999, the infection was eradicated, at least from commercial poultry flocks (Ryan et al 2000).

Although there is an endemic strain of Newcastle disease virus present in the national flock, it is non-pathogenic. Fowl plague has never occurred in New Zealand.

Conclusions

Many endemic diseases of livestock in New Zealand already have been or will likely be, eradicated. Our history shows an evolution from programmes driven by the public sector for what was seen as the public good (sheep scab, bovine brucellosis, hydatids, anthrax and, for many years, bovine tuberculosis), through facilitation of an industry-initiated scheme (Aujeszky's disease), to ones managed by animal industry groups (bovine tuberculosis nowadays; EBL in dairy cattle; infectious bursal disease). In addition, there are voluntary control schemes that have the potential to eradicate diseases such as caprine arthritis encephalitis and ovine brucellosis.

Any incursion of a serious epidemic (OIE List A) disease will be managed by government agency and, at least in the first instance, dealt with using the stamping out method in accordance with long-standing policy.

As a result of these programmes and policies, New Zealand enjoys an enviable status of freedom from or control of many of the serious diseases that affect livestock in the world today.

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Hydatids

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