

Appendix B

Literature Review

B.1. Introduction

It was clear from the beginning to those promoting a scheme for the eradication of Bovine Tuberculosis in Ireland that the task that lay ahead would be protracted, arduous and costly. There was, however, little real alternative to launching such a scheme, given the progress being made on eradication in the United Kingdom and the increasing likelihood that Irish cattle would be progressively squeezed out of a market on which this country then depended quite heavily. Concerns for the health of the human population also played a part in the decision, but these were of a secondary nature in comparison to the need to maintain trade, as is evidenced by the following extract from the debate on the Diseases of Animals (Bovine Tuberculosis) Bill of 1957:

Senator O'Donovan rightly reminded us that bovine tuberculosis also constitutes a potential “danger to the human subject”. I just want to remind the House that, when it seemed to constitute a danger to the human subject only and not to the cattle trade, it was regarded as a matter of relative unimportance, not half as important as the foot and mouth disease question. The money “could not be found” to compensate for slaughter, as it is now being found after all, because now the British market is going to close to us unless we eradicate tuberculosis from our cattle.

(Seanad Éireann)

Steady progress was made from the beginnings of the Programme in 1954, right up to 1965, when the country was declared to be attested (free of disease). A report by the Department of Agriculture and Food¹ published in 1965 (Watchorn) shows that, over this period, animal test reactor incidence² was reduced from 17% to just 0.44%. The incidence of the disease in animals, which was as high as 22% in cows at the scheme's inception, had fallen to just 0.28% across all animal categories by 1966. The Watchorn report is succinct and descriptive, rather than prescriptive, detailing the historical background to the scheme, enumerating the principal milestones in its history to date, and ending with the affirmation that the only counties then remaining to be attested – the six southern dairying counties - would have ‘*become attested before the end of 1965*’ (ibid.). It is perhaps indicative of the substantial and rapid progress made in eradicating tuberculosis up to that time, that the Watchorn report contains no recommendations for the improvement of the scheme, and that such obstacles to eradication as are described are either presented as having been overcome by subsequently introduced corrective measures, or are merely enumerated without further comment.

The relatively sanguine perspective from which Watchorn reports on progress towards eradication in the mid 1960s stands in contrast to the study carried out twenty years subsequently by Robert O'Connor (O'Connor). Here, clear evidence is provided that the State's considerable investment in Tuberculosis eradication had begun to give diminishing returns from the period just following national attestation in 1965. From 1966 onwards, herd incidence had begun to increase once more, reaching 7.5% in 1977, before levelling off again at 3.2% in 1985. The comparison with the earlier period is dramatic. While the twelve years from 1954-1965/66 had brought about an eight-fold reduction in herd incidence for a total net cost of £368.8m, a similar level of expenditure over the following twenty years (£361.3m) had failed to bring about a further reduction in disease levels, the number of reactors removed oscillating within a range of twenty-two and forty-five thousand *per annum* over that time³. O'Connor divides the eradication programme into two periods, falling on either side of the watershed year of 1965:

The first period runs from 1954 when the scheme was initiated, up to 1965 when the whole state was declared officially free of the disease by the Minister for Agriculture. The second period runs from 1965 to the present time when there is still a relatively high incidence of disease in the State.

(O'Connor)

Although the scheme's shortcomings had been known and written about for some time previously, O'Connor's study was the most comprehensive attempt to marshal all of the (then) known obstacles to the eradication of Bovine Tuberculosis. Furthermore, the plethora of individual problems besetting the Programme, none of which, of themselves, seemed to threaten the viability of the Programme, were now being presented as a complex capable of derailing the eradication scheme. Five years later, following the period during which the Programme was administered by ERAD [B.4], it was apparent that the correction of the practical totality of the deficiencies identified in the pre-ERAD programmes had had little or no impact on the level of disease. Reviewing the legacy of the ERAD programme in 1991, Sheehy and Christiansen argued that the most important outcome of the ERAD initiatives had been to demonstrate the fallacy of the historic criticisms of the BTEP. The clear conclusion that could be drawn was that

The objective cannot be eradication until the technological means of doing so are available.

(Sheehy & Christiansen)

The approach that is taken in the remainder of the literature review is thematic, rather than strictly chronological. Following an exploration of the Programme's objectives, the various eradication strategies pursued from the Programme's inception up until the end of the period of ERAD management are presented. The succeeding sections will examine some of the constraints to eradication that have been identified in the literature, including those relating to the funding of the programme and to the *detection*, *resolution* and *containment* of infection. The final section summarises the literature relating to what is generally recognised to constitute the most significant constraint to the eradication of bovine tuberculosis in this country; namely the existence of a reservoir of infection in the badger.

B.2 Programme objectives

Statements made in the Houses of the Oireachtas when the Diseases of Animals (Bovine Tuberculosis) Bill, 1957, was being debated indicate that the objective of the programme from the beginning was to bring about the complete eradication of bovine tuberculosis. While the difficulties that lay ahead were by no means underestimated, it is clear that eradication was seen as being attainable within a finite (albeit undefined) period of time. Introducing the Bill, then Minister for Agriculture, Sean Moylan, T.D., stated:

(I)t is hardly necessary for me to stress the importance and the magnitude of the task which confronts us in the eradication of bovine tuberculosis. This is, I think, fully appreciated by Deputies on all sides of the House and has been endorsed by all sections of interested public opinion. I trust that everybody realises that complete eradication will necessarily be an arduous, a fairly long and a very costly job, requiring the full co-operation of every herd-owner in the country. It is not an impossible job. That has already been amply demonstrated in other countries where the fight against the disease is now well advanced or has been won.

(Dail Eireann 1957a)

There was a strong sense that the road ahead had already been mapped out by other nations that had embarked on eradication programmes long before Ireland. The message

emerging from these jurisdictions tended to suggest that progress in the Irish scheme would follow a known path, the end point of which – complete eradication – would be reached sooner or later, as a function of the resources devoted to the task. The immediate objective of maintaining access to the British market was rapidly secured, and the feasibility of achieving the ultimate objective of eradication was regarded with varying degrees of optimism in the period following National Attestation up to the creation of the national disease eradication Board (ERAD) in April 1988. The mood of the period has been summed up in the following terms:

The objective of eradication was innocently embraced in the early years of the scheme, and the early progress in reducing the disease level tended to confirm the achievability of the objective. The declaration in 1965 of full attestation was the climax of the mood. By the early 1970s it was clear to the informed that the disease was not eradicated, but the aspiration of imminent eradication was maintained.

(Sheehy and Christiansen)

Although events in the period following 1965 had dented the optimism of those that believed progress towards eradication would be continuous, if slow, it was not until 1991, following the period of ERAD administration of the programme that the objectives were explicitly revisited. The objective of the programme, which might previously have been expressed in an undifferentiated fashion as the ‘eradication of bovine tuberculosis’ was now explicitly restated by the Board of ERAD as consisting of three, temporally sequential objectives progressing from the control of the disease to its reduction, and finally its eradication [see also B.4 and 2.3 in body of report].

The almost contemporaneous report on the Scheme by Sheehy and Christiansen similarly emphasised that the development of new technology would be critical to overcoming the barriers that lay in the way of eradication:

The objective of eradication is a laudable and prudent one in a rich world which can afford to be increasingly concerned about human health and the safety of its food. But that objective will remain a mere aspiration until the investment is made to generate the technology to realise it.

(ibid.)

B.3 Eradication strategy

B.3.1 The early period

The eradication strategy adopted in the early days of the programme is well described by Watchorn (1965). It was based on the gradual reduction of disease incidence in selected areas until a point was reached at which the area could be declared attested. The initial stage of the programme was voluntary⁴ and it was open to any herdowner to participate, availing of free testing facilities and full market compensation for cow reactors. Once disease incidence in a given area was driven down sufficiently through voluntary effort, a compulsory control system came into operation in which all herds in that area were obliged to carry out herd tests, all reactors were removed and cattle movements became subject to strict control. Area attestation was achieved when the majority of the herds in the area had completed three complete rounds of testing.

It quickly became apparent, however, that the degree of interest in the programme on the part of herdowners varied markedly across the country, being greatest in the western counties, and least in the midlands and south. In the case of the southern counties, the lack of interest was explained, at least in part, by the fact that the agricultural economy of this region depended to a greater extent on the sale of milk than on the production of store cattle. Two years after its commencement, and in light of this knowledge, the programme was modified with intensive control measures applying to eight counties in the west of the country⁵, the remaining territory availing of the newly-created Attested Herds Scheme. The following year, the enactment of the Diseases of Animals (Bovine Tuberculosis) Act, 1957 provided statutory authority for the compulsory eradication of bovine tuberculosis. The new Act was an enabling measure, empowering the Minister for Agriculture to make Orders for the progressive eradication of bovine TB; it also authorised payment of compensation for reactors and defined 'compensation' as meaning the value that an affected animal would have had as a non-reactor on the open market.

In October 1957, Sligo became the first Clearance Area in the country, and as such was subject to compulsory eradication measures. By March of the following year, six other western counties were added to the Clearance Area and the intensive, voluntary regime was extended to Cork, Limerick and three northwestern counties. When the Watchorn

report was published in October 1963, all counties with the exception of the six southern dairying counties had achieved attested area status, and the clear expectation was that the southern counties would follow suit 'before the end of 1965'.

B.3.2 The ERAD period

The Eradication of Animal Disease Board (ERAD) was established by government in April 1988 with the objective of planning and implementing a vigorous four-year programme to accelerate the eradication of bovine TB and brucellosis. The overall objective set by ERAD at the time of its inception was to reduce prevailing disease levels by half. The National Director of ERAD was delegated authority by the Minister for the overall management of the programme, including staff engaged in the operational aspects of the schemes and research. Upon its establishment the Board comprised the Chairman and nine members, representing the Irish Farmers Association, the Irish Creamery Milk Suppliers Association, the Irish Cooperative Organisation Society, the Irish Veterinary Union, the Irish Veterinary Association, the Department of Agriculture and Food and the Department of Finance.

The TB eradication strategy adopted by ERAD on its establishment set out to address the four principal weaknesses that had been identified in pre-existing programmes of eradication – inadequate funding and the inadequate detection, containment and resolution of disease. The first was dealt with by the government commitment to provide continuous funding over a four-year period. This undertaking extended to all of the administrative costs of the four-year programme as well as the provision of £9.6m *per annum*, towards the running costs. A further £22m would be provided through disease levies (ERAD, 1988). Thus, with its financing assured, ERAD management was free to design a strategy to address the technical impediments to disease eradication, relatively unencumbered by the constraints that had bedeviled previous schemes.

The remaining, technical weaknesses were to be addressed in three phases. The first phase, operative from February 1989 onwards, was designed to maximise the rate of extraction of TB infected cattle from the national herd, thereby reducing the potential for disease transmission from cattle-to-cattle. The second phase, which began in March 1990, aimed to further reduce the levels of bovine TB by reducing the sources of

residual infection, including badly or non-tested infected cattle, infected wildlife (especially badgers), anergic⁶ and parallergic⁷ infected cattle, and environmental contamination. The third phase, which was intended to become operative from January 1992 onwards, was to prioritise the control of the geographic spread of the disease by establishing a computerised movement permit system that would allow *inter alia* for the targeting of disease control measures and the implementation of zonal and herd-based clearance strategies (ERAD, 1990). Progress from the control to the reduction phase was conditioned on the development of:

- Certain organisational arrangements [see B.4.5];
- An insurance system;
- A pre-movement test system; and
- A herd/area classification system.

Progress from reduction to eradication was seen, in turn, as depending on:

- Development of a badger vaccine;
- A laboratory-based diagnostic test; and
- A computerised movement permit system.

By 1991, despite having overseen the performance of some 44 million tests on the national herd of approximately 7 million cattle and the simultaneous introduction of an extensive range of support measures, ERAD had clearly failed to achieve its objective. Summing up the impact of the intensive eradication programme undertaken in the period 1988-1991, Downey concluded that there was little evidence that the programme had had the expected impact on the prevailing levels of bovine TB.

The outcome of the ERAD programmes points to the fact that exhaustive testing, even when combined with (an) extensive range of support measures.... may not be capable of getting ahead of the disease. At best, such programmes may be sufficient to crop the annual growth of reactors, with the possibility of progress in certain areas or regions.

(Downey, 1991)

Looking back over the period of ERAD's mandate, Downey found reasons internal to the programme as well as others lying outside it for the failure to achieve its objectives.

Internal to the programme, he recognised that the work undertaken by the Board did not adequately provide for meeting what he described as the necessary pre-conditions for a successful eradication programme: proper testing; an effective means of removing infected badgers; control of cattle movement; adequate manpower resources; and fuller farmer commitment. External factors, including the inadequate understanding of the dynamics of disease between cattle and susceptible wildlife reservoirs, had also significantly impeded progress and, unless addressed, would continue to circumscribe the potential of future eradication programmes (Downey, 1992).

B.3.3 Beyond ERAD

... it is clear that the present scheme is operating at the limits of current knowledge of the dynamics of bovine TB and also of the available technology. For significant progress, and possibly ultimate eradication, future programmes must be driven by research and technology, supported by the appropriate laboratory and related technical services.

(ibid., original emphasis)

Future research, Downey contended, must be channelled into the development of: a vaccine for TB in badgers and/or cattle; a laboratory-based diagnostic test for bovine TB and; a computerised movement permit system. Significant progress would be required in all three of these areas, as well as in the understanding of a variety of socio-economic constraints, before eradication could realistically be achieved. The long-term strategic approach to the management of the disease must reflect this reality, by establishing short-, medium- and long-term goals consistent with the state of development of the organisational, technological and financial resources available to the programme at any given point in time.

From the perspective of the early 1990s, Downey concluded that the most realistic option for the future was that of a least-cost control programme that permitted the necessary investment to be made in the scientific and technological tools that would be required to permit eventual eradication of the disease.

B.4 Constraints to eradication

B.4.1 Disease dynamics

In a paper delivered in 1990 by the then Director of the Eradication of Animal Disease (ERAD) Board, the remarkable success of the eradication strategy up to 1965 was contrasted with the almost total failure to make further inroads against bovine TB in the period just following national attestation in 1965 (Downey, 1990). While the period 1959 – 1962 had seen the removal of between 120,000 and 160,000 reactors *per annum*, the rate of removal of reactors dropped to about 40,000 in 1964 and thereafter remained at an annual figure of about 30,000, up to the time of establishment of ERAD in 1988. This is not to say, however, that the disease pattern remained static over these years; hidden behind the more or less constant aggregate national figure, Downey identified an important spatial dynamic, falling either side of what he described as a ‘watershed’ year in bovine TB eradication.

The year in question was 1975 and it marked a sharp reduction in the disease prevalence in southern counties accompanied by the beginnings of a steady increase, from very low levels, of the prevalence in the northern part of the country. Downey suggests that this phenomenon was the consequence of a number of unrelated events that occurred almost contemporaneously around this time, *viz.* the crisis in cattle prices at the end of 1974, the veterinary dispute in 1975 and the enactment of the Wildlife Act (1976), which provided statutory protection to Ireland’s badger population. In his view, the hiatus in the testing regime brought about by the veterinary dispute allowed for the movement into northern counties of untested, infected cattle from the southern counties. The fact that this uncontrolled movement of infected cattle coincided with a period of rapid expansion of cattle numbers in the northern counties and with a general, countrywide increase in badger numbers led Downey to hypothesise that, from the mid-1970s onwards, bovine TB had become self-sustaining in the northern counties and that it ‘may, indeed, be spreading outwards from there’ (*ibid.*). This is not the only disease dynamic referred to by Downey; quoting investigations by Crilly, he describes how bovine disease levels undergo both an intra-annual, seasonal cycle and an inter-annual thirty month cycle. An interesting feature of the latter is that it presents a small downward slope, equivalent to about 0.9 % in the reactor rate *per annum*; extrapolating from this underlying downward trend, Downey calculates that, if it were to continue, it would mean that ERAD’s target

of halving bovine TB from the levels pertaining in 1988 would not be achieved until 2015 (ibid.).

B.4.2 Programme funding

The absence of continuous, adequate funding to the programme was identified as a significant impediment to eradication both in the O'Connor report and subsequently by the National Director of ERAD (Downey, 1990, 1991). In O'Connor's view the many discontinuities in funding had contributed to the Programme becoming

... no more than a holding operation which stops the disease from reaching an unacceptably high level but (which) will never reduce it to a sufficiently low level.

(O'Connor)

Drawing attention to the fact that the level of exchequer funding directly determines the extent of testing that is possible, he showed that while 137%⁸ of the national herd had been tested in 1985, the corresponding figures for the previous two years had been just 61% and 45%, respectively. In addition, he contended, the eradication of bovine TB in Ireland would not be possible in the absence of a continuing commitment to monitor *all* herds in the country, no matter how wasteful it may seem to regularly test cattle in areas where disease levels are apparently low (ibid.).

The solution proposed by O'Connor to the problem of inconsistent and inadequate funding was to adopt a system of programme financing in which some of the costs are paid for by farming organisations, with the government, in turn, legally obliged to provide a matching contribution, at a fixed proportion of that of the farmers. As the principal beneficiary of the eradication programme is the farmer, rather than the state, he argued, it is the farmer who should bear the major portion of the costs. A contribution from farmers of the order of 75% of the programme's variable costs would be 'reasonable', leaving the state to absorb the residual variable costs and those fixed expenses that would continue to be incurred even when eradication is finally achieved. Apart from reducing the state's financial exposure to the cost of running the programme, the assumption of greater levels of responsibility by farmers, linked to the actual costs of running the programme, would create an incentive on their part to eliminate the disease as quickly as possible. Complete elimination of levies could be triggered when disease levels fell to some agreed level (ibid.).

Although farmer contribution to the programme has fallen short of the level proposed by O'Connor [see 5.4.1 in body of report], the financial constraints to eradication were effectively removed by the government commitment to provide continuous funding to ERAD over the four-year period of its operation and by the continued maintenance of adequate levels of funding from both government and the farming community since that time.

B.4.3 Farmers' attitudes towards the programme

The attitude of the farming community towards the disease has received some attention in the literature. Sheehy and Christiansen (1991), for example, state that tuberculosis in cattle is seen as the Department's problem, despite the fact that *'the main losers and potential gainers from more effective disease control are farmers themselves'*. While this attitude might have been expected when the Scheme was fully funded by the taxpayer, they comment, it is much more difficult to understand given the *'increasing contribution of farmers to the cost of the Scheme in recent years'* (ibid.). In seeking an explanation for the apparent lack of ownership of the TB eradication programme on the part of farmers, the authors point to the absence of a linkage between the collection of bovine disease levies and the adoption by the individual farmer of reasonable disease prevention measures. They suggest that the transformation of the disease levy into a compensation fund to be managed by farmers would have a positive influence on farmer behaviour and hence on the efficiency of operation of the programme.

A study of the socio-economic impediments to bovine TB eradication, carried out in 1993, found that over 40% of their farmer respondents⁹ did not believe themselves to be primarily responsible for the protection of their herds. A separate finding was that only 7% of 'category A' herdowners (high disease risk) and 2% of 'category D' herdowners (low disease risk) ranked disease control as being of major importance when presented with a range of farm management parameters (O'Connor et al.).

B.4.4 The detection of infection

The intradermal test

In accordance with European Union legislation (Directive 80/219, Annex B), just two intradermal tests are approved for use by member states in their bovine TB eradication

programmes; these are the *Single Intradermal Test* (SIT) and the *Single Intradermal Cervical Comparative Test* (SICTT). The former is regarded as being unsuitable for use in Ireland and the United Kingdom, as the level of non-specific infection would result in 6-12% of cattle being erroneously classified as reactors. The comparative test is therefore the test of choice in these countries, as it has been in many others in which the disease has been successfully eradicated (Monaghan et al.).

A major review of the tuberculin test carried out by Monaghan et al. (1994) described how the accuracy of the SICTT has two components – sensitivity and specificity – which are measures of the ability of the test to correctly identify animals with disease and non-diseased animals, respectively. While the ideal test would have a sensitivity and specificity of 100%, no biological tests are known to have achieved such accuracy and, furthermore, the two parameters are negatively correlated i.e. increased sensitivity is associated with reduced specificity, and vice versa. The accuracy of the SICTT is also dependent on the prevalence of tuberculosis in the population under test; the higher the prevalence the more likely it is that a positive test is predictive of the disease. Thus the *positive predictive value* of tuberculin tests is likely to be higher in the earlier stages of an eradication campaign than in the later stages. The converse is true of the negative predictive value of the test i.e. the likelihood of a test negative animal not having the disease (ibid.).

The failure of cattle infected with tuberculosis to give a positive reaction to the SICTT can be attributed to a range of factors. Monaghan et al. summarise these as follows: the existence of a time delay between infection with the disease and the development of reactivity to the test; the failure of certain cattle to develop reactivity to the test (anergy); reduced reactivity to the test for a period (42-60 days) following the injection of tuberculin; immunosuppression in the early *post-partum* period (and possibly also in malnourished cattle). In a separate review, Good et al. (unpublished) add that the sensitivity of the SICTT will be influenced by the potency and dosage of the tuberculins injected, the chronicity and extent of disease in the tested population, and by the parameters used to interpret the observed changes in skin measurement. In addition, variation in test results may also arise because of differences between observers and variations in readings by the same observer. The reduction of such observer variation requires the standardisation of procedures, training, and periodic quality control of

standards (Monaghan et al.). The review of various studies of the SICTT carried out by Monaghan et al. suggests that test sensitivity lies between 77 and 95%, while Good et al. cite research by O'Reilly (1993) indicating that the sensitivity of the SICTT under Irish conditions lies in the range of 91-98%.

The specificity of the SICTT in a particular environment will depend amongst other things on the levels and types of non-specific infection in the population, the purity and dosage of the tuberculins injected and the parameters used to determine the test result. The proportion of test reactors attributable to non-specific infection will tend to rise as eradication programmes progress due to the existence of a persistent level of non-specific sensitisation arising from infection with *M. paratuberculosis*, *M. avium*, or skin tuberculosis, or as a result of the presence in the environment of certain non-pathogenic mycobacteria (Good et al.). However, the fact that the majority of test reactors fail to show lesions of tuberculosis on slaughter, or to give a positive result to bacteriological examination, cannot be taken to mean that these cattle have not been infected with or exposed to *M. bovis*. An immune response in the infected animal, detectable via the SICTT, develops well in advance of the pathological changes that must take place if evidence of infection is to be detectable at post-mortem examination. Under the conditions pertaining in Ireland, the specificity of the SICTT has been reported by Monaghan et al. to be at least 99%, and by Good et al. to be at least 99.95% under Irish conditions.

Despite the fact that the SICTT is the best available diagnostic test for bovine tuberculosis, its less than perfect reliability has led many reviews of the Programme to include an exhortation for further research into the development of a reliable blood-based test. O'Connor's (1986) review, for example, asserts that a reliable blood test would provide a solution to many of the problems associated with the SICTT, such as the difficulty of interpreting it correctly under field conditions, and variability in the standard of testing. His conclusion at the time was that the prospects of such a test becoming available at the time of publication of his report were 'remote, despite heavy expenditure throughout the world on research in this area'. Over the intervening period, however, just such a test – known as the interferon-gamma assay (IFN- γ) – has, in fact, been developed. The properties of this test and the potential for its application in programmes of eradication of bovine tuberculosis are discussed below.

Interferon-gamma (IFN- γ) assay

A review of the diagnosis of *M. bovis* infection in cattle using the IFN- γ assay by Gormley et al. (2006) describes how the test works by detecting cytokines – compounds associated with the cell-mediated immune response typically found in the early stages of bovine tuberculosis. The sensitivity of the test in infected herds is reported to range between 55% and 97%, depending on the interpretation used, while the specificity in tuberculosis-free herds has been reported to be of the order of 97%. The assay has been recognised under Directive 64/432 as an adjunct to the tuberculin test and its use in infected herds has been recommended by the EU tuberculosis sub-group of the task force. Under Irish conditions, the combined sensitivity of the IFN- γ test and the severe interpretation of the SICTT has been shown to be higher than that achieved using either test alone. On the other hand, a separate study of clear herds showed that the specificity of the IFN- γ assay, at 95%, falls far below that of the SICTT, rendering it inappropriate for use as a screening test in herds that are likely to be free of tuberculosis. A third, longitudinal, study of IFN- γ positive animals in infected herds demonstrated that the prompt removal of all IFN- γ positive animals can significantly reduce the risk of disclosure of reactors to the SICTT at subsequent reactor retests (ibid.).

Gormley et al. concluded that the IFN- γ assay, when applied strategically as an adjunct to the tuberculin test can facilitate the early removal of infected animals in problem herds that are otherwise negative to the SICTT. For the purposes of general surveillance testing, however, the use of the SICTT, when accompanied by knowledge of the epidemiological risks associated with individual herds and by effective meat plant inspection, is adequate for surveillance purposes and eradication, as has been the experience in many countries (ibid.).

Variability in the application of the SICTT

Variability in the application of the SICTT by veterinary surgeons is a matter that has come in for some attention in the literature. Thus, for example, an early documentary record of the operation of Ireland's eradication programme (Watchorn) makes reference to the discovery (in 1959) of 'irregularities on the part of a small number of veterinary surgeons in the carrying out of the 14-day test'. The effect of these, according to the author, was the appearance of a disproportionate numbers of reactors when exported

cattle were subsequently retested in Britain, and the consequent damage to the reputation of Ireland's 14-day test in the eyes of the British authorities.

By the early 1970s the lack of progress with eradication, combined with the persistence of doubts over the accuracy of tuberculin testing, led to the establishment of a task force of fifty veterinary inspectors (TVIs), engaged by the Department for the purpose of comparing reactor incidence with that of private veterinary practitioners. The results of this exercise indicated that the incidence of reactors as identified by the task force was two-three times that disclosed by private practitioners. Some years later, an *ex post* review of tuberculin testing data for 1979-1985, undertaken on behalf of the Department, similarly pointed to substantial differences in the rate of reactor detection as between DVO veterinarians and private practitioners, the latter group disclosing substantially fewer reactors than the former. These results were, however, open to criticism on the grounds that the reactor disclosure rate of Department veterinarians contained an inherent upward bias, given that this group tended to concentrate more heavily on at-risk herds than would be the case for private practitioners.

Herdowner nomination of the testing veterinarian

The arrangement by which the herdowner allocates the private veterinarian to carry out tuberculin testing on his/her behalf can be traced back to the time of the scheme's introduction in 1954, when the Department reserved only limited rights to nominate a veterinarian of its own choice. In 1983, a joint review group from the Departments of Agriculture and Finance (Depts. of Agriculture & Finance, 1983) examined the herdowner-veterinarian arrangement in the context of a review of the Tuberculosis and Brucellosis eradication schemes and concluded:

There is ample evidence that this close relationship between the herdowner and veterinary practitioner who normally does his (sic) testing has been damaging to the Bovine Tuberculosis eradication programme.

(ibid., p.8)

The principal recommendation of the joint review group was that the Minister for Agriculture should reserve the sole right to nominate the veterinarian to carry out Tuberculosis testing. This recommendation was given added weight in the government's

National Plan 'Building on Reality 1985-1987', paragraph 7.36 of which called for the replacement of nomination of testing veterinarians by farmers with their direct nomination by the Department. Under the terms of an agreement between the Department and the Irish Veterinary Union in 1985, the Department's right to allocate testing to a veterinary practitioner of its choice was recognised. Nonetheless, little change to the practice whereby veterinary surgeons tested their own clients' herds was observed by O'Connor in the review carried out the following year (O'Connor).

Ireland's arrangements for the allocation of veterinary surgeons to individual herds found themselves subject to scrutiny from the institutions of the European Union over the course of the next decade. In 1989 the EEC had sought to attach conditions relating to the allocation of veterinary surgeons and to the alternation of testing between private and official veterinary surgeons to the proposed co-financing of pre-movement testing in the Irish programme (Morris, 1990). Although the difficult national Exchequer position of the time precluded the scheme's adoption by the Irish government on that occasion, a similar issue arose again in 1997, when the European Commission sought to make funding of Ireland's eradication programme conditional on the implementation of a system of alteration between private and state veterinarians. On this occasion, the Department was able to show to the Commission's satisfaction that the required level of 'rotation' of veterinary personnel had taken place, and was subsequently able to draw down funding in the amount of IR£4.5m from the European Union's Veterinary Fund.

B.4.5 The resolution of infection

The apparent inability of the programme up to 1990 to ensure that trading restrictions on individual herds were maintained until residual infection had been eliminated was identified as one of three fundamental factors constraining the successful prosecution of the eradication programme in the assessment of the then National Director of ERAD (Downey, 1990). Evidence for this position was, it was claimed, provided by the 'unacceptably high percentage of herds that break down on the six month check test, having been cleared to trade following two successive reactor retests which disclosed no reactors'. In 1989, the rate of breakdown six months following derestriction averaged 10% nationally and reached 20% in certain counties, both figures comparing unfavourably with the general rate of breakdown of 4% for herds subject to routine

‘monitor testing’. The implication of these figures, according to Downey, was that between one in ten and one in five herds that were being restored to trading status at that time may, in fact, have continued to pose a serious threat to TB-free herds. While accepting that many factors, including the presence of infected badgers, may be responsible for the high rate of breakdown, Downey nonetheless suggested that the failure to remove all infected animals during the period of the herd’s restriction is at least a contributory factor.

In considering how strategy might be reshaped to address this threat, Downey referred to the eradication programmes of the US, Australia and New Zealand, where herds are designated according to the degree of infectivity of the disease episode they are undergoing, and the path to derestriction is adjusted accordingly, being shortest in the case of single reactor breakdowns (singletons) in herds with otherwise good health records and longest in those with infective type breakdowns. Downey’s proposal was that, as a first step to introducing similar measures in Ireland, herds would need to be designated as Confirmed Free Herds, Provisionally Clear Herds, or Restricted Herds, with extended periods of restriction applying to those experiencing infective breakdown episodes. Trading between Provisionally Clear Herds would be possible via a special identity card system, while cattle from Confirmed Free Herds would enjoy a market premium when presented for sale at marts. The claim made in favour of such a system was twofold: by ensuring that infection remained locked up, it would protect the national herd; and by offering special health status to Confirmed Free Herds it would bring market orientation to the eradication programme.

The element of Downey’s proposal relating to the treatment of herds in which a single reactor is disclosed has been incorporated into the present programme under the protocol applying to ‘Singleton’ herds [see 6.3.4 in body of report]. The proposed differentiation between confirmed and provisionally free herds was never adopted, however. The proposal met with resistance from the farming industry, which argued that such a system would go significantly beyond the terms of Directive 64/432 and would introduce unnecessary complexity into the management of the programme.

B.4.6 The containment of infection

In relation to the control of the geographic spread of the disease, it has been argued that the very high level of cattle movement in Ireland¹⁰ is ‘unquestionably one of the main reasons why bovine TB has not been eradicated’ (Downey, 1990). Movement to sales and marts were said to provide an opportunity for contact between cattle, some of which may be carrying infection, and this risk is compounded by illegal movements of cattle. The assessment made at the time was that such risks could only be addressed by the introduction of a computerised movement permit system, which would, *inter alia*, provide assurances as to an animal’s health status prior to movement, facilitate the tracing of reactor and incontact animals, enable the introduction of targeted control measures, and expedite the detection and investigation of illegal movement (*ibid.*). The history of, and certain of the literature relating to, the use of pre-movement testing as a measure aimed at enhancing the containment of infection is discussed in Chapter 8 of the main report [8.2.1].

Control of cattle-to-cattle transmission is just one element of a disease containment strategy; the literature would suggest that cattle-to-cattle transmission is, in fact, of lesser importance than transmission between cattle and infected wildlife (particularly the badger) in the maintenance of disease. More and Good (2006), for example, state that preliminary analysis of breakdowns occurring in the reference area of the Four Area Project [B.10.5] shows that approximately 75% of these can be attributed to the presence of badgers. This analysis is closely corroborated by recent research in Great Britain, which attempted to quantify the proportion of transmission attributable to cattle movements as compared to that due to other causes. The British study concluded that, of the various models of disease transmission constructed, the best explanation of bovine TB breakdowns in 2004 was provided by a model attributing 16% of herd infections directly to cattle movements and a further 9% to unexplained causes. The best-fit model assumed low levels of cattle-to-cattle transmission and attributed the remaining 75% of infection to local effects within specific high-risk areas (Green et al.).

The final section of this review summarises the considerable body of work that has developed in relation to the containment of the spread of infection *via* wildlife reservoirs, particularly the badger, generally recognised to represent the single most significant constraint to the eradication of bovine tuberculosis in this country.

B.5 Wildlife and bovine tuberculosis

B.5.1 Background

The literature that has grown up around the role of an infected wildlife reservoir in the maintenance of Tuberculosis in cattle in Ireland is both extensive and of relatively recent appearance. A measure of the paucity of the information available just twenty years ago is provided in Robert O'Connor's study, in which he quotes personal communication with the then Deputy Director of Veterinary Services to the effect that:

The Department, while not ruling out the role of the badger in spreading the disease, gives it a low priority. They claim on the basis of their evidence to date that cattle contact is by far the greatest cause at the present time...

(O'Connor)

O'Connor's review does not include any recommendations in relation to the investigation of possible interrelationship between the disease in cattle and that in badgers and other wildlife species and references to the possible implication of wildlife in the maintenance of bovine disease in Ireland are confined to a single paragraph in the report. The experience of the United Kingdom is covered somewhat more extensively in the introductory section of O'Connor's review, where it is stated that

It is now fairly well established that badgers serve as carriers of the bovine tubercle bacillus and are likely to infect cattle in areas where there are high badger and cattle densities as, for example, in South West England and probably in many parts of Ireland.

(ibid.)

The link between tuberculous badgers and cattle in the United Kingdom can be traced back to epidemiological investigations undertaken in 1971 and to two major inquiries carried out in 1980 and 1984. The first of these inquiries – the Zuckerman Report – concluded that badgers are responsible for the relatively high incidence of the disease in south-west England and recommended that a so-called "clean ring" strategy be introduced in which all badgers were to be culled (by gassing) in the area of an outbreak until a clean ring of uninfected badger setts was established (Zuckerman). The implementation of Zuckerman's recommendations meant a return to the policy of gassing badgers that had begun in 1975 and which was temporarily suspended in 1979, pending the completion of his enquiry. Public opposition to gassing and the active

resistance on the part of animal welfare groups, together with concerns about the humaneness of the use of hydrogen cyanide gas, led to the abandonment in 1982 of gassing and its replacement by cage trapping and humane destruction (O'Connor and O'Malley). By the time a committee under the chairmanship of Professor G.M. Dunnet published its findings some four years after Zuckerman, the recommendations in relation to the role of wildlife were considerably more nuanced than those of its predecessor. While concluding that badgers 'may constitute the main source of re-infection of cattle with bovine tuberculosis' and that a badger control policy was therefore necessary, Dunnet nonetheless emphasised that the many gaps in the knowledge of the epidemiology of the disease in badgers counselled a cautious approach to the problem (O'Connor). The principal recommendation of the Dunnet Report was that the government of the United Kingdom should adopt an 'interim strategy' in which action would be taken against the badger at farm-level, rather than in wider geographic areas, and only in cases where no other source of infection had been found and where there was evidence to suggest the involvement of badgers in other recent break-downs in the area. The policy of clearing whole areas of badgers was thereby discontinued.

B.5.2 Building the evidence base

In Ireland, despite the fact that the first tuberculous badger was detected in 1974 (Noonan et al.), evidence suggesting a causal link between infection in that species and in cattle emerged only slowly over the next decade. In October 1986, just two months before O'Connor's review appeared in print, Dr. Kevin Dodd, an epidemiologist at the Faculty of Veterinary Medicine in UCD, was stating in a letter to the *Irish Times*:

Wildlife in general but badgers in particular come under intense scrutiny as a possible source of bovine TB when a herd has a recurrent pattern of breakdown, despite the diligent application of conventional control methods ...
(O'Connor and O'Malley)

Although Dr. Dodd's views were receiving support from an increasing number of other commentators at about this time, the contrary view was also beginning to find its way into publication. In a letter to the *Irish Times* on 1st December 1988, Dr. J.M. Barry of the Irish Wildlife Federation rejected as 'unscientific' the hypothesis that badgers were implicated in breakdowns in the Galway/Offaly/Longford area, citing in defence of this

argument the views of the ‘scientific staff of the Department of Agriculture’ to the effect that transmission to cattle occurs only in ‘very isolated cases’ (ibid.).

While the questions being raised in the mid- to late-1980s about the possible role of wildlife in the maintenance of bovine tuberculosis were of a very serious nature, the formulation of a clear government policy was seriously impeded by the lack of sound scientific investigation in an Irish context. The publication, in 1989, of a report by Robert O’Connor and Eoin O’Malley entitled *Badgers and Bovine Tuberculosis in Ireland*, represented the first major attempt to fill this policy vacuum. In this report the authors carried out an extensive review of the available international knowledge on the subject and collated the results of investigations and other evidence from a variety of Irish sources. The report recognised that many weaknesses in the operation of the bovine tuberculosis eradication scheme contribute to the failure to eradicate the disease, but that these were insufficient, of themselves, to explain the dramatic ‘flare-ups’ of the disease, increasingly prevalent since the late 1970s¹¹. The results of separate badger removal programmes under Irish conditions (in Offaly, Cork, Galway and Longford) had convinced the authors that badger removal, combined with intensive testing ‘seemed to have played important roles in the disease reduction in these areas’, but that these experiments needed to be extended longitudinally in order to allow firmer conclusions to be drawn. O’Connor and O’Malley specifically rejected the suspension of badger capturing activity pending the outcome of a number of research projects then underway on the grounds that there was already ‘substantial’ evidence from both the United Kingdom and Ireland to implicate the badger in transmission of disease to cattle. The overall thrust of the report is neatly summed up in the final two conclusions which it reaches:

...eradication of the badger population would not eradicate bovine TB in the country.

It is also true to say that in many areas of the country it may not be possible to control bovine TB without controlling the badger population.

(ibid.)

The following year, an external consultancy report prepared for ERAD on the operation of the BTE Scheme was published (Morris and Pfeiffer). Although the report examined many aspects of the scheme’s operation, the principal question to which it addressed

itself was that of the significance of the wildlife reservoir as a source of infection of cattle. In the view of these authors, the most controversial technical issue for TB control in Ireland was that of establishing the proportion of the problem that could be attributed to the badger. In their opinion the available evidence would suggest that this was '*larger rather than smaller*', and that badgers were likely to be '*seeding infection into the cattle population at many locations throughout the country*' (ibid.). Nonetheless, the badger, of itself, was thought to provide an inadequate explanation for the observable pattern of infection, leading the authors to balance their conclusions with the statement that cattle-to-cattle transmission would '*appear to account for a substantial part of the high reactor numbers found*' (ibid.).

The Morris and Pfeiffer report concluded that, in the absence of improved technological resources, intensification of the established methods of eradication beyond the levels required to provide for the annual truncation of infection within the bovine population would not be cost-effective. A residuum of infection, attributable to the 'seeding' effect of infected wildlife on the bovine population, would remain refractory to conventional approaches and would, of itself, be sufficient to maintain existing levels of infection in cattle into the foreseeable future. Any resources additional to those required to 'crop' infection within the bovine population would be more cost-effectively employed in developing new technologies, particularly those aimed at resolving the problem posed by infected wildlife reservoirs. To this end, the report recommended that the Department utilise the significant information resources held on its computerised databases to develop a model of disease transmission under Irish conditions, while simultaneously progressing research aimed at delivering a vaccine for use in badgers or cattle, or in both species. While it was not envisaged that vaccination would provide a complete solution to the TB problem in Ireland, the authors argued that it was '*difficult to see a complete solution being achieved without a vaccine*' (ibid.).

East Offaly Badger Research Project

Of the research projects cited by O'Connor and O'Malley, probably the most significant was the East Offaly Badger Research Project (EOBRP), which commenced in 1989. While previous studies in Ireland had provided some evidence to suggest that the control

of tuberculous badger populations was associated with an improvement in the tuberculosis status of bovine herds in the vicinity, none had provided for designated control areas to allow for contemporaneous comparison. This was a defect that the EOBRP set out to remedy. The results of the trial, which ran for six years until 1995, showed that, by reference to the baseline year 1988, there had been a reduction of 91% in the APT¹² in the Project Area (from which badgers were removed), as compared to a decrease of 38.1% in the Control Area (Dolan). The results of this Irish study corroborated those obtained in a similar exercise carried out over a much smaller area in the southwest of England (Clifton-Hadley et al.). An additional finding was that the badger removal programme also had an effect on the badger population in the surrounding Control Area; 50% of the badgers trapped in the last three years of the study were located in the Buffer Area between the Control and Project Areas (Dolan et al.). This is significant in that it indicates that the dynamics of the badger population subject to systematic control are such as to have ‘an influence on the tuberculin testing outcome of some of the cattle herds in the Control Area’ (Dolan). Commenting on the significance of these results, Dolan cautions against extrapolating directly from them to other areas where badger numbers and cattle density may vary considerably from those obtaining in East Offaly. Similar caution is exercised by O’Mairtin et al. (1996) who, despite confirming that control of the tuberculous badger population in the Project was accompanied by a reduction in the level of infection in cattle, point out that the project design lacks replication, thereby limiting the extent to which conclusions can be applied to other locations.

Four Area Project

Soon after the results of the EOBRP were being disseminated, another paper was published, outlining the design of a separate, more ambitious badger removal trial (Griffin, 1996). This trial, which became known as the Four Area Project (FAP), sought to address some of the deficiencies of the EOBRP by providing for four separate removal areas (in Counties Cork, Donegal, Kilkenny and Monaghan), each containing matched badger removal and reference areas. Critically, the study design incorporated measures to address the possibility of extensive badger immigration following removal of badgers, a phenomenon that had been identified in the EOBRP (Dolan et al.; Eves). These included the selection of the removal areas so as to maximise the presence of

natural geographic boundaries and the use of buffer areas between the removal and reference areas. The project ran from September 1997 to August 2002, and the results were published in 2005 (Griffin et al. 2005, 2005a). The study demonstrated that there was a significant difference between the probability of a confirmed restriction occurring in the badger removal and reference areas, respectively. In addition, the time to a confirmed herd restriction due to tuberculosis was found to be significantly different in the two areas. The odds of a confirmed herd restriction in the removal area (as compared to the reference area) were 0.25 in Cork, 0.04 in Donegal, 0.26 in Kilkenny, and 0.43 in Monaghan. Moreover, the rate at which herds were becoming the subject of a confirmed restriction during the period of the project was reduced by between 60% and 96%. Significantly, the project demonstrated a consistent effect across all four counties (ibid.).

Criticisms of the effectiveness of badger removal as a strategy for reducing levels of bovine tuberculosis in the cattle population have been voiced in the United Kingdom over recent years. These criticisms, and the Department's response to them, are dealt in the body of the report [6.4.3 – 6.4.6].

B.5.3 Badger vaccination

The production of significant research demonstrating the beneficial effects on bovine tuberculosis levels of controlling tuberculous badger populations did not alter the view that the widespread removal of badgers did not represent the optimal long-term solution to the problem of bovine tuberculosis. Of the possible alternative policies that began to find their way into publication, that of vaccination of the badger is by far the most prominent. A joint report by the Departments of Agriculture of Ireland and Northern Ireland (1994) concluded that the development of a vaccine for use in the badger represented a feasible option for the control of bovine tuberculosis.

That same year a major consultation report of the World Health Organisation (WHO), Food and Agriculture Organisation (FAO) and OIE (World Organisation for Animal Health) on animal tuberculosis vaccines was published (WHO, 1994). The scope of the consultation was to review strategies for control of animal tuberculosis, to review the state of knowledge regarding tuberculosis vaccine development for humans and animals, and to produce a comprehensive set of recommendations for animal tuberculosis vaccine

research and development. The report concluded that the economic benefits of a vaccine in wildlife species would be judged by the outcome in the target species (cattle), and that the fact that it would not be necessary to achieve protection at the level of the individual animal in the vaccinated species would potentially reduce development costs. Assessing the prospects of a fifteen-year path to the development and application of a vaccine, the report recommended that fundamental research be undertaken in at least three major areas: the pathobiology of *M. bovis* in domestic and wildlife species; the nature of the immune response in target host species; and the construction of appropriate vaccines and the development of diagnostic tests compatible with the use of these vaccines. Countries (such as Ireland) in which wildlife hosts represent an impediment to the elimination of tuberculosis were urged to undertake medium- (six-year) and long-term (fifteen-year) studies to incorporate vaccination in an integrated optimal disease control strategy applicable at the national or regional level (ibid.).

Irish researchers recognise that badger vaccination, if proved to be feasible, provides a means of reducing the severity of tuberculous lesions in badgers, thereby reducing their infectivity for cattle and bringing about positive outcomes for disease levels in the bovine population. The essential components of a national badger vaccination programme have been identified (Gormley and Costello) as consisting of the following elements:

- A detailed investigation of the prevalence of disease in the badger population as well as the distribution of infected animals among the general population;
- The development of sensitive and specific diagnostic tests for the presence of tuberculosis in badgers, capable of differentiating *M. bovis* infection from the vaccine-conferred immune response;
- The development of a vaccine capable of conferring persistent immunity on the badger; and
- The development of a reliable system for vaccine delivery.

Preliminary investigations, published in 1998, sought to evaluate the immune responses of badgers to vaccination with the *M. bovis* BCG vaccine (Southey and Gormley, 1998). These authors concluded that, while the badgers did develop an appropriate immunological response to the vaccine, further work would be required on its enhancement by investigating the effects of changes *inter alia* in the vaccination protocols, dosage rates and routes of administration. In subsequent research, the same authors found that lymphocyte activity is positively correlated with numbers and severity of tuberculous lesions in infected badgers and that a blood-based test known as Lymphocyte Transformation Assay (LTA) can be used to rapidly and readily identify both infected and diseased animals (Southey and Gormley, 1999). A further development, reported in 2003, was the establishment of a protocol for the experimental infection of badgers by the respiratory route, an essential prerequisite for subsequent testing of the vaccine in the target species.

Thus, in summary, a number of the elements that would be required in order to instigate a full badger vaccination programme have already been described in the literature. In addition, experience outside of Ireland has given cause for moderate optimism regarding the future of the badger vaccination project. Perhaps the foremost example is that of the success achieved in reducing the incidence of fox rabies in France. There, a biannual oral vaccination regime has proven more effective than the traditional shooting and gassing of fox populations. Over a ten-year period the incidence of rabies in France has decreased by 99 %. In some other areas of Europe rabies has been completely eliminated and vaccination is no longer required (Aubert, 1996). Similarly, the preliminary results of studies on the vaccination of wild brushtail possums in New Zealand using live attenuated *M. Bovis* BCG (Corner et al.) give additional cause for guarded optimism in relation to a future large-scale badger vaccination project in Ireland. Irish and international research on the vaccination of badgers, meanwhile, continues apace [see Appendix J].

NOTES

¹ Henceforth, the abbreviation ‘The Department’ will be taken to refer to the Department of Agriculture, Fisheries and Food (and all its previous denominations). Where any other government Departments are referred to their full title will be used.

² The figures for incidence must be interpreted with caution; they are not comparable from year to year because of different testing intensities in the different years (O’Connor)

³ Expenditure data in constant (1985) prices

⁴ When the programme began in 1954, the first areas selected for the initial voluntary phase were Clare, Sligo and the Bansha area of Tipperary (Watchorn).

⁵ Clare, Donegal, Galway, Leitrim, Mayo, Roscommon, Sligo and Kerry (Watchorn).

⁶ Infected animals that pass the skin test, but which are detected by other means, such as the discovery of visible lesions on post-mortem examination.

⁷ Infected animals that pass the skin test due to the presence of a large concurrent reaction to the avian tuberculin.

⁸ Because an individual animal may be tested on more than one occasion in the course of a year, the number of animal tests performed *per annum*, expressed as a percentage of the number of animals in the national population, may exceed 100%.

⁹ The survey carried out by O’Connor et al. was administered to 919 farmer respondents, stratified into four disease categories.

¹⁰ Estimated at the time to be of the order of 12 million cattle movements per annum.

¹¹ O’Connor and O’Malley (1989) point to a ‘marked increase in the badger population’, which they attribute to a number of factors, viz.: the Wildlife Act of 1976, which provided legal protection to the species; increases in the land area under woodland and plantation; increased earthworm populations (as a result of greater fertiliser use); and reduced snaring of foxes.

¹² The number of reactor animals per 1,000 animal tests