MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

BADGERS AND BOVINE TUBERCULOSIS – REVIEW OF POLICY

Report to the Rt Hon Michael Jopling, MP, Minister of Agriculture, Fisheries and Food, and the Rt Hon Nicholas Edwards, MP, Secretary of State for Wales

by Professor G M Dunnet
BSc, PhD, DSc, FRSE, FI Biol, FRSA
(Regius Professor of Natural History at the University of Aberdeen)

Mr D M Jones
B Vet Med, BSc, MRCVS, FI Biol
(Director of Zoos of the Zoological Society of London)

Professor J P McInerney
BSc, Dip Ag Econ, NDA, PhD
(Glanely Professor of Agricultural Policy at the University of Exeter)

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PREFACE

To the Rt Hon Michael Jopling, MP,
Minister of Agriculture, Fisheries and Food

March 1986

and

the Rt Hon Nicholas Edwards, MP,
Secretary of State for Wales

Dear Sirs

In your Press Notice of 20 September 1984, you announced that you had asked us to undertake a review of the Government's policy on badgers and bovine tuberculosis and that you proposed to make our findings public. We were given the following terms of reference:–

> "To conduct an overall review of the problem of dealing with badgers infected with bovine tuberculosis insofar as it affects the eradication of the disease in cattle, taking into account changes in the field and research work since Lord Zuckerman reported on the problem in 1980".

In presenting our report we should like to record our appreciation of all those organisations and individuals who have taken the time to submit written evidence and, in some cases, discuss that evidence with us; not least amongst these have been your own officials.

GEORGE DUNNET
DAVID JONES
JOHN McINERNEY

Secretary to Review: Richard Jeffery

PART I—DESCRIPTION

CHAPTER 1

BOVINE TUBERCULOSIS IN GREAT BRITAIN—A BRIEF HISTORICAL REVIEW

1. We confine ourselves at this point to a brief description of tuberculosis in cattle, the history of the attempts made to eradicate the disease from cattle in Great Britain, the involvement of badgers (*Meles meles*), and the events which led to this review of policy being undertaken.

Tuberculosis in cattle

2. Tuberculosis in cattle is caused by the bacterium *Mycobacterium bovis (M.bovis)*. When tubercle bacilli invade the body either an acute, or a chronic, inflammatory reaction occurs. In the acute form, considerable quantities of fluid, containing large numbers of white blood cells and fibrin, are produced. Usually in cattle this form is associated with acute pneumonia and is now extremely rare in Great Britain. More frequently, the chronic form of the disease occurs. In this situation invading bacilli become enclosed by a mass of inflammatory cells and the classic "tubercle" is formed. Layer upon layer of these cells are added but the inner layers ultimately die off as a result of the effect of the bacterial toxins and form a necrotic core. Tubercles are typically 1–20 mm across, are usually rounded in shape and white, grey or pale yellow in colour.

3. In cattle, tubercles are most usually found in the pulmonary system, both in the lung tissue and on the pleural membranes. The associated lymph nodes will also contain the lesions. Less frequently such lesions are seen associated with the digestive system in the mesentery and associated lymph nodes. Only in advanced cases will lesions appear in the udder, uterus and skin, and such cases are very rare in this country. If lesions do occur in these organs the animal is much more likely to excrete the bacteria and so become an "open" case. Where the disease becomes so advanced that significant areas of pulmonary tissue become involved, bacilli will also be ejected by coughing. More rarely, severe cases affecting the digestive tract will lead to the organism being excreted in the faeces. The renal system is almost never involved in cattle, a situation very different to that in badgers.

4. With regular tuberculin testing of herds, it is far less likely nowadays that cases of tuberculosis in cattle will progress to the point where the animal is actively excreting living organisms before the disease is detected. By far the majority of cattle showing lesions on *post mortem* examination were infected but not infectious. In other words they contained tubercle bacilli, but because the number of organisms was small or because the organisms were enveloped by layers of inflammatory cells, the animals were not excreting significant numbers of living bacteria and were therefore not infectious, i.e. liable to pass the infection, to other animals.

5. Because of its more typical chronic progressive nature in cattle, the principal outward signs of the disease are of reduced milk yield and loss of weight. In retrospect it is clear that, if the disease incidence had not been greatly reduced, the development of the beef and dairy industries to their present form could not have occurred. Increased herd size with feeding and housing under intensive conditions would have been impossible, and exports of cattle and dairy products would not have been allowed under international trading rules. There was also a threat to public health from direct contact with infected cattle or from drinking infected milk—although pasteurisation has overcome the latter problem except in areas where milk or milk products are sold untreated.

History of eradication of bovine tuberculosis in cattle

6. Earlier this century bovine tuberculosis was one of the most serious diseases of cattle in Great Britain. The initial efforts to combat the disease had only limited success and a Committee on Cattle Disease, under the Chairmanship of Professor Sir Frederick Gowland Hopkins, reported in 1934 that at least 40% of cows in dairy herds were infected with tuberculosis. The first voluntary national programme for the eradication of the disease was introduced in 1935 but had to be halted during the war years from 1939 to 1945. In 1950 the present compulsory eradication campaign started on an area by area basis. Areas were declared to be attested after all herds had been tested twice and all cattle which gave a positive reaction to the tuberculin test ("reactors") had been removed for slaughter. By 1960 all areas in Great Britain had been declared attested. This did not mean that the disease had been eradicated, but that the incidence of disease had declined to what were regarded as negligible levels. In 1960 the incidence of reactor herds was about one herd in fifty.

7. The incidence of reactors in Great Britain continued to fall over the next ten years except in south west England where the situation remained relatively static. A special field study of the problem was undertaken in west Cornwall by Ministry veterinarians between 1970 and 1972, and they considered that a number of factors might have a bearing on the problem. One of their recommendations was that wildlife be examined to see if any species constituted a reservoir of infection for cattle.

Infection in badgers

8. In 1971 a badger, which had died from generalised tuberculosis due to *M. bovis,* was found on a Gloucestershire farm where the infection in cattle had recently been confirmed. The farmer who found the badger had been suspicious that diseased badgers were the source of infection in his cattle. This case, and the recommendation mentioned in paragraph 7, led to investigations to measure the prevalence of tuberculosis in badgers in the area and their role as a potential reservoir of *M. bovis* for cattle. In the light of these investigations the Ministry concluded in 1973 that badgers were such a reservoir, and that action was required to deal with infected badgers where they posed a threat to the health of cattle.

9. Although tuberculous lesions have been noted in all the major organ systems, it is the respiratory and urinary systems which are most frequently affected in the badger. The tubercles are relatively small (1–4 mm), well defined, soft, spherical and usually pale grey in colour. In some cases they replace extensive areas of the affected organ and in advanced pulmonary cases a large quantity of pus is present in the air passageways. In advanced renal cases, considerable quantities of pus collect in the renal pelvis and then in the bladder. Sputum and urine are therefore likely to be the main sources of bacteria leading to cross infection of other animals. It is considered that many renal cases are secondary to pulmonary infection although some probably result from bite wounds. Tuberculous skin abscesses are fairly common and result in most cases from fight wounds. The digestive system is rarely affected although intestinal ulcers and hepatic nodules are occasionally reported. The associated lymph nodes may also be affected. Although the lesions are similar to those in cattle, caseation, calcification and encapsulation of the tubercles are rarely seen in badgers. One of the most important differences is that much greater numbers of bacilli are found in badger lesions than in bovine lesions.

10. Initially, in circumstances where infected badgers were considered to pose a threat to the health of cattle, Ministry officials gave advice to the herd owner on killing the badgers on his farm, by trapping, shooting or snaring. However there was considerable public disquiet, particularly about snaring, and live trapping techniques were felt to be too cumbersome and time consuming. The Ministry concluded that the only satisfactory method of killing badgers, being both effective and humane, was to gas them in their setts with hydrogen cyanide gas. This conclusion was accepted by the conservation and animal welfare organisations. The Badgers Act 1973 (a protection measure) authorised Agriculture Ministers to issue licences for the killing of badgers to prevent the spread of disease. This power was modified by including in the Conservation of Wild Creatures and Wild Plants Act 1975 a provision which, in effect, permitted the use of gas to be specified in such a licence. During the passage of the latter Act in Parliament an undertaking was given that licences for gassing would be issued only to staff of the Ministry or to persons under Ministry control. The Government also announced its decision to set up a panel of representatives of interested organisations, which the Ministry would consult in connection with the measures needed to deal with the problem of bovine tuberculosis in badgers. The panel was established as the Consultative Panel on Badgers and Tuberculosis and met for the first time in September 1975. Gassing operations commenced in August 1975.

11. Gassing operations authorised by licences were subject to the agreement of occupiers of land to permit access, and this highlighted the lack of adequate powers to deal with any disease of significance to livestock that could become established in wildlife (except rabies, for which legislation had already been passed). Accordingly provisions were included in Sections 9 and 10 of the Agriculture (Miscellaneous Provisions) Act 1976 enabling Agriculture Ministers to make Orders, after consulting with the Nature Conservancy Council, defining areas in which they could undertake action against wildlife to prevent the spread of disease to farm livestock. These Sections, which have since been consolidated into the Animal Health Act 1981, included powers of entry to land for investigational and surveillance purposes as well as for control operations. Following consultations with the Nature Conservancy Council, the Badgers (Control Areas) Order 1977 was made. The Order defined four Control Areas in south west England—two in Cornwall, one in Devon and one comprising Avon and parts of Gloucestershire and Wiltshire (see map on page 11). Outside of those statutory areas, which have remained unchanged, operations are still subject to the voluntary agreement of occupiers insofar as taking of badgers is concerned.

Lord Zuckerman's review

12. In the light of continuing public criticism, which focused on the likelihood of infected badgers passing on the disease to cattle and on the methods used to kill badgers, the then Minister asked Lord Zuckerman in September 1979 to take an objective look at the problem and to advise how it should be tackled in the future. From 25 September 1979 gassing of new areas was suspended until 30 October 1980 when the Minister announced his acceptance of Lord Zuckerman's recommendations. In doing so the Minister expressed his gratitude for Lord Zuckerman's assessment of a complex and controversial subject.

13. Having considered all the evidence Lord Zuckerman concluded that on scientific grounds it was clear that badgers constituted a significant reservoir of bovine tuberculosis; furthermore, the high density and close proximity of the cattle and badger populations in parts of south west England favoured the transmission of the disease, not only from one infected group of badgers to another, but also from badgers to cattle. In the light of this conclusion, and taking into account statistical evidence which suggested to him that the disease in badgers in some parts of the south west seemed to have spread during the suspension of control operations in new areas, Lord Zuckerman recommended that those control operations against badgers should be resumed as soon as possible. In making this recommendation he pointed out that the Ministry's activities did not constitute a threat to the survival of the badger nationally. Lord Zuckerman's full report was published under the title "Badgers, Cattle and Tuberculosis".

14. All fourteen of Lord Zuckerman's recommendations were accepted and Ministry officials have supplied us with a summary of the action that has been taken to implement them; this is reproduced as Appendix 1.

15. One of Lord Zuckerman's recommendations was that investigations should be conducted into the action of hydrogen cyanide in order to establish what concentrations of the gas in the air of a sett would be needed to kill badgers quickly and humanely. Such experiments were conducted by the Chemical Defence Establishment. In July 1982 the then Minister concluded from the results of the experiments that there had to be doubt as to whether all the badgers in a gassed sett died quickly, and therefore whether they died humanely. He announced to the Consultative Panel on Badgers and Tuberculosis that gassing would no longer be used as the main method of badger control. The full text of that announcement is reproduced as Appendix 2. Following

consultations with the Consultative Panel on Badgers and Tuberculosis, and subsequently with other interested organisations, the then Minister announced that live trapping followed by humane killing had been adopted as the main method of badger control but that it was to be subject to continuous appraisal. The Consultative Panel had advised that they were satisfied live trapping was a practicable and humane means of control. They emphasised that trapping would result in badger carcases being available for scientific investigation and urged that every effort should be made to advance scientific knowledge of this problem.

Further review of policy

16. Another of Lord Zuckerman's recommendations was that there should be a further overall review three years after his own report was published. In September 1984 the Minister announced that he and the Secretary of State for Wales had requested us to undertake such a review. We were given the following terms of reference:—

"To conduct an overall review of the problem of dealing with badgers infected with bovine tuberculosis insofar as it affects the eradication of the disease in cattle, taking into acount changes in the field and research work since Lord Zuckerman reported on the problem in 1980".

CHAPTER 2

CURRENT POLICY AND PRACTICE

Basic presumptions

17. At the outset of our review, we asked the Ministry for its definition of "eradication" as it is applied to bovine tuberculosis in cattle. The Ministry replied that the relevant statutory authority (Section 3 of the Animal Health Act 1981) provides powers for the Minister to take action to eradicate diseases of agricultural animals "as far as practicable". The Ministry's current view is that the eradication policy objective for bovine tuberculosis in cattle should be to achieve that degree of disease freedom defined in Article 3.14 of EC Council Directive 64/432 on animal health problems affecting intra-Community trade in bovine animals and swine. That definition relates to the degree of disease freedom that must be achieved before a Member State can discontinue regular tuberculosis testing. It requires that at least 99·9% of all bovine herds have been declared officially tuberculosis free for at least 10 years, and additionally that every year for at least 6 years bovine tuberculosis should not have been found to be present in more than 1 herd in 10,000. The Ministry went on to say that in any eradication programme a pragmatic approach had to be adopted. For tuberculosis they have a final objective, detailed above, which would define the point at which eradication measures could safely be ended. In the shorter term, however, their objective is simply to reduce the level of the disease and any reduction is considered a gain. Perceptions of what may prove to be the practicable level of eradication may change with increasing knowledge of the problems to be faced.

18. Tuberculosis in cattle has been eradicted from every farm in the country and the remaining problem is one of re-infection. All herds have been declared officially tuberculosis free for more than 10 years. However every year bovine tuberculosis is still found in more than 1 herd in 10,000 in Great Britain. In 1983 bovine tuberculosis was identified in one herd in 1,770 in Great Britain, and in 1984 the rate was one herd in 1,860. The Ministry recognises that where badgers are infected with tuberculosis they constitute a potential reservoir of the infection for cattle, and therefore represent the remaining major constraint on achieving the objective of eradication of the disease in cattle. Their presumption is that action must be taken therefore to remove infected badgers. The Ministry define their current "policy" on bovine tuberculosis and badgers as being "to protect as far as practicable cattle herds from re-infection with bovine tuberculosis from the reservoir of infection in badgers", and they have adopted a control "strategy" to attempt to achieve this.

Detection of herd breakdowns

19. The implementation of the policy to eradicate tuberculosis from the national cattle population is based, in the main, on the identification of herds with infected animals. Now that clinical signs of tuberculosis in cattle are rare, this is achieved by regularly testing the national herd and monitoring cattle carcases at slaughterhouses, knackers' yards and hunt kennels. When infected cattle are identified the incident is described as a "herd breakdown".

20. The tuberculin test used in Great Britain compares the immunological response to avian and mammalian tuberculins injected intradermally; bovine tuberculin replaced tuberculin produced from human (*M.tuberculosis*) strains in 1975. This method of testing cattle involves the measurement of the thickness of a fold of skin before, and 72 hours after, injection of the two tuberculins at sites on the neck approximately 15 cms apart. The test is interpreted by a comparison of the inflammatory skin reactions to the two tuberculins. The differences in the skin reaction are judged more critically in herds where there has been a recent history of confirmed tuberculosis in the herd ("severe interpretation") and less critically where there is no such confirmed history ("standard interpretation"). An animal that fails the test is termed a reactor and must be isolated pending removal for slaughter. An animal which gives an inconclusive result is termed an inconclusive reactor and must be isolated and re-tested after an interval of between 42 and 60 days. If after a second re-test the result is still inconclusive the animal is classified as a reactor.

21. The frequency of tuberculin testing is specified with a view to ensuring that breakdowns are detected at an early stage and spread of disease between cattle is prevented, paying due attention to the cost of the programme and inconvenience to farmers. Three-yearly testing is used to monitor herds where disease incidence has proved to be very low and is the normal procedure for most of Great Britain. However, where the probability of disease is greater, as in parts of south west England, the testing is generally carried out every two years. Herds within which tuberculosis has been diagnosed continue to be tested at frequent intervals until they are confirmed as being free of infection. In addition, where breakdowns have occurred frequently, whole parishes or groups of parishes can be put on to annual testing. This strict regime applies to large areas of the counties of Avon, Gloucestershire, Wiltshire and Cornwall and to groups of parishes in a few other counties. Further, in the areas where testing is carried out every three years, it is usual to test only the adult herd, other animals in contact with them and recent purchases; in the annual testing areas all cattle are tested.

22. In Great Britain the meat inspection procedures used in slaughterhouses are designed to detect the tuberculous animal. In every bovine carcase, those lymph nodes and organs most likely to be affected with tuberculosis are examined carefully and where there is a suspicion of tuberculous lesions, the meat inspector calls in a qualified veterinary surgeon. If the veterinary surgeon is also suspicious of the carcase, the suspected lesions, and other parts of the carcase if necessary, are sent for laboratory examination. The Ministry then sets

in motion the procedures to trace the herd of origin of the suspect animal. Where the distribution and appearance of the lesions in the carcase are typical of tuberculosis, the herd of origin is immediately treated as an infected herd. Where there is doubt about whether the lesions are due to tuberculosis, such action may be delayed until the results of the laboratory examination are known, although this is not the case if the herd is situated in an area where tuberculosis is common.

Summary of procedures "on the farm"

23. In all herd breakdowns, the Ministry serves notice on the owner of the herd that all reactors must be slaughtered and may also require that other animals, which are deemed to have been in close contact with infected animals, be slaughtered as well. These other animals (known as "dangerous contacts") may include for example, a calf of an infected dam, a calf fed on milk from a tuberculous udder or animals kept in the same building or field as a known infected animal. The herd owner has the option to sell all animals so identified for slaughter privately, but may elect for the Ministry to make the arrangements for slaughter. In the latter case the Ministry pays compensation at the rate of 75% of market value for reactors (subject to a variable monthly maximum based on market prices) and 100% of market value for the dangerous contacts.

24. All reactors and dangerous contacts are examined *post mortem*. To confirm the presence of tuberculosis in the herd, whether lesions suggestive of tuberculosis are found or not, samples are submitted for laboratory examination (see also paragraph 22 for slaughterhouse cases). Laboratory confirmation of the diagnosis in cattle is regarded as essential because the tuberculin test cannot be regarded as 100% accurate. In the laboratory the diagnosis of infection with *M.bovis* depends on the isolation of the bacterium from lesions, or from lymph nodes taken from animals which do not show lesions. This is done through a combination of culture on selective media, inoculation into guinea pigs and skin testing of the guinea pig. These tests take some six to eight weeks to complete. If no visible lesions have been found in the animals taken from a herd and the organism is not recovered on laboratory examination of samples, the herd breakdown is regarded as "unconfirmed" and the herd is usually regarded as free of the disease after a single clear tuberculin test 60 days after the test that initially identified the reactors. If either visible lesions have been found, or a positive laboratory result has been received, the herd breakdown is regarded as "confirmed". Two consecutively clear tests at 60 day intervals are required before the breakdown is considered to be over. For the duration of a herd breakdown, movement of cattle onto and off the farm is prohibited except under licence. Animals may be moved directly to a slaughterhouse, but other animal movements are curtailed.

25. Wherever infection is confirmed in a herd, the tracing of recent movements of cattle onto and off the breakdown farm is given a high priority. The origin of animals brought onto the farm is traced in order to determine whether they may have been the source of infection, whilst movements off the farm are traced in order to find whether infection might have been carried to other herds. In addition to the more permanent movements, the hiring of animals and movements to temporary grazing are also considered. All the herds in the vicinity of a herd breakdown are subjected to a tuberculin test to check whether there has been any transmission of disease to or from contiguous farms. Where cattle do not appear to be the source of infection for the herd breakdown the veterinary investigation pursues other avenues such as the possibility of transmission of the disease from humans or other species. As far as humans are concerned, both direct transmission from farm personnel and indirect transmission by cattle coming into contact with sewage are considered. Enquiries are made about the clinical histories of other species on the farm (particularly pigs, goats, dogs and cats). In exceptional circumstances such animals may be tested.

26. Where infection has been confirmed in a herd, but where the origin has not been identified by the veterinary investigations, consideration is then given to the possibility of infected badgers being involved and a "preliminary badger investigation" is instituted. This involves initially a survey of the farm to determine the number of setts and the distribution of any badger social groups. Badger social groups have well marked and stable territories within which they move. There is currently no test to detect tuberculosis infection in living badgers, so to establish whether the badgers are infected a sample of carcases or, exceptionally, badger faeces has to be taken. The identification of infection in badgers follows a similar pattern to that used for cattle, although detailed techniques differ. A badger is regarded as infected if either (a) gross lesions and acid fast bacilli are found on *post mortem,* or (b) *M.bovis* infection is isolated from badger samples on culture in the laboratory. The laboratory tests for badgers, which normally do not involve the use of guinea pigs except for testing badger faeces, again take some six to eight weeks to complete. If *M.bovis* is not isolated from the sample, the investigation will usually be closed. However, if the organism is isolated a "badger removal operation" follows.

27. The sampling component of the preliminary badger investigation is waived in two sets of circumstances. Where an infected badger is discovered accidently (usually from carcases found and reported by a member of the public) in an area where cattle are at risk, a badger removal operation may then follow after the group to which the badger belonged has been identified and without need for further confirmation of infection. Such cases are the subject of prior discussion with local members of the Consultative Panel on Badgers and Tuberculosis (known as a "mini-Panel"). The other set of circumstances in which no sampling is undertaken prior to a badger removal operation is where a breakdown occurs in one of the problem areas of south west England and where all three of the following criteria set by the Ministry are met: (a) the farm history indicates clearly that infection in cattle could have originated from badgers, (b) tuberculosis is known to be endemic in badgers in the area and (c) the survey component of the preliminary badger investigation confirms that the breakdown farm (or part of the farm where the infection is suspected to have been contracted) is being used by badgers. The local mini-Panel is informed of such cases.

28. Badger removal is conducted, in the main, by cage trapping animals and then humanely killing them. Operations follow a strict pattern of the removal of all members of social groups identified as having infected badgers, plus contiguous social groups. All the badgers removed are subject to *post mortem* and laboratory examination. If any of the contiguous social groups are shown to contain infected badgers, the removal area is enlarged to include those groups; this continues until a "clean ring" of groups containing no infected individuals has been found and removed, or the removal operation reaches an area where there is no badger activity. A full description of the strategies employed is given at Appendix 3. In all cases, at the completion of the badger removal operation, the re-establishment of badgers in the cleared area is prevented by further trapping for six months to avoid any risk of the incoming badgers becoming infected from live bacilli remaining in the badger setts. This is referred to as the "maintenance" phase of the operation. Subsequently, natural recolonisation is allowed.

29. The present arrangements for badger operations show some changes from the practice when gassing was the main method of badger control. The methods of sampling the badger population then were much the same but, once infection had been confirmed in badgers, the area to be gassed was determined by consideration of the location of breakdown farms, infected badgers taken as samples or picked up as road casualties, the likely grouping of setts and physical boundaries. The objective was to gas all infected badger social groups and groups in contact with them. No further check could be made on the disease status of the gassed badgers as their carcases remained underground in the blocked setts. Once the initial gassing had been completed it was intended that setts would be revisited at three-monthly intervals for two years to attempt to prevent immigrant badgers from acquiring infection from the setts and to monitor the health status of badgers reoccupying the area. Any setts which appeared to be reoccupied during the first twelve months were regassed. If reoccupation was found after twelve months then some samples of badger carcases or faeces were obtained for laboratory examination. The second year was referred to as the "monitoring" phase of the operation. If any samples were positive for *M.bovis* then regassing of the setts occurred and monitoring continued.

CHAPTER 3

DISTRIBUTION AND INCIDENCE OF BOVINE TUBERCULOSIS

Incidence in cattle

30. Data on the distribution and incidence of the disease in cattle are provided by the Ministry. The geographical distribution of cattle herds in which an outbreak of bovine tuberculosis was confirmed from 1979 to 1984 is shown on the maps at pages 8 and 10. The maps also indicate the origins of infection attributed by the veterinarians of the Agriculture Departments following their investigations of these confirmed herd breakdowns (N.B. Maps showing equivalent data for the years 1972 to 1978 were reproduced in Lord Zuckerman's report). It appears that, in south west England, herd breakdowns in recent years have been concentrated in Avon, Gloucestershire, north Wiltshire, Cornwall and Devon (particularly in the north west of the county and on Dartmoor). In the same period in the rest of the country the main problem areas appear to have been in Dyfed and Staffordshire.

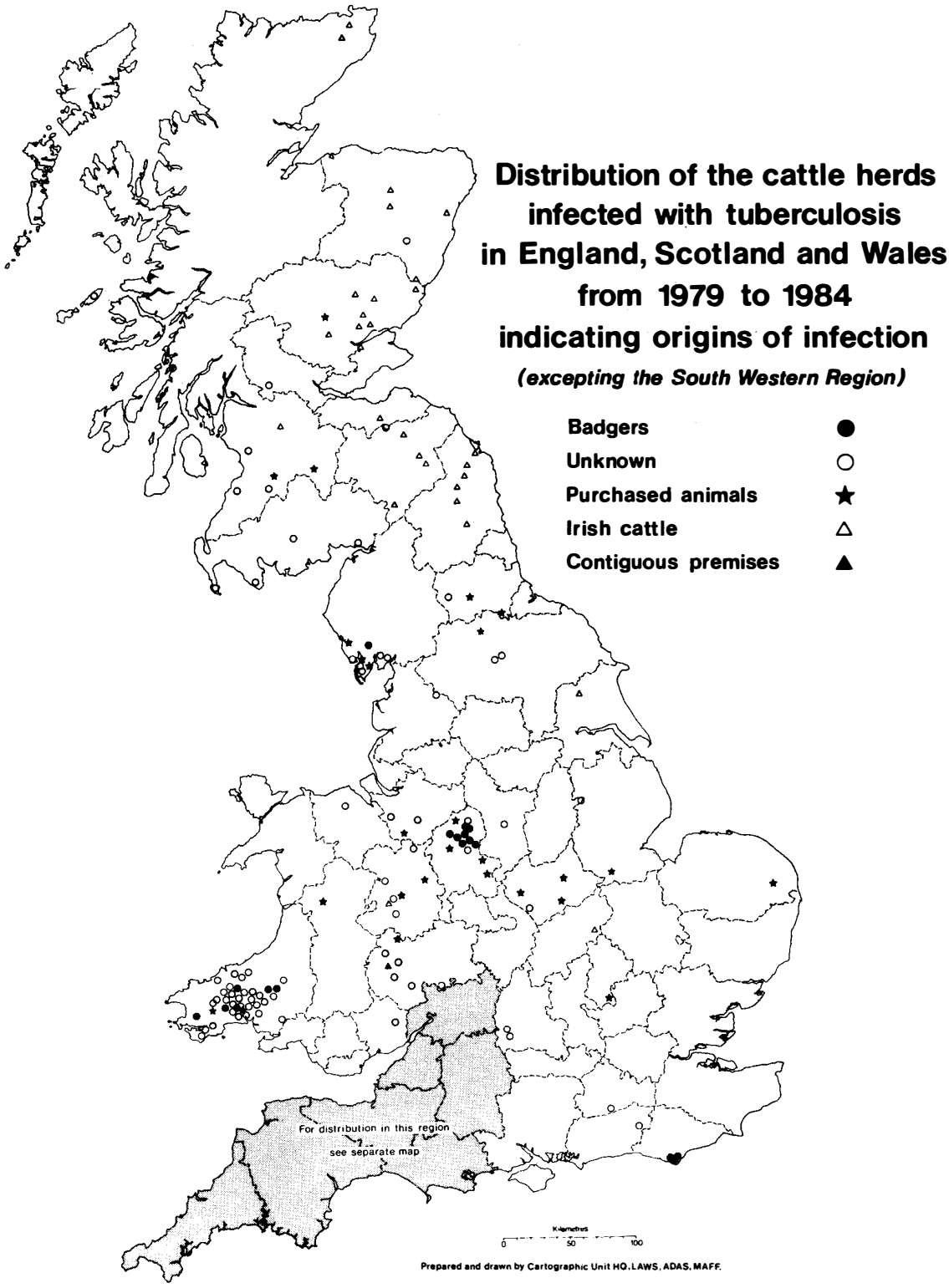
31. The graph at Appendix 4 enables some comparison to be made between the incidence of disease in south west England and the rest of the country. We prefer to base our analysis on the number of reactor herds, rather than on the number of reactor animals, which have been used elsewhere. The number of reactor herds gives a better indication of the amount of primary exposure to infection whereas the number of reactor cattle is more a function of the extent of infection within herds. To obtain comparable annual incidence rates the Ministry had to try to take account of the facts that (a) the frequency of tuberculin testing has changed over the time period (the major change was from biennial testing, up to 1973, to triennial testing from 1974) and (b) testing is more frequent in areas where there is a higher risk of cattle becoming infected. The annual incidence rates, being the ratio of the number of reactor herds disclosed in a year to the total number of herds at risk in that year, are regarded as best estimates. Factors affecting changes in these estimated annual incidences of reactor herds are discussed in Part II of this report. However, the trend in the observed incidence of tuberculosis outbreaks in cattle herds does provide a valuable guide in judging progress towards the Ministry's policy objective.

32. The data in Appendix 5 relate to confirmed breakdowns but the graph at Appendix 4 is based on all reactor herds, whether confirmed subsequently or not. Because of the inevitable element of fallibility of both the tuberculin test and the laboratory methods used to confirm bovine tuberculosis in reactors, one cannot be sure whether the reactor herds in which the disease was not subsequently confirmed were associated with exposure to *M.bovis* or not. The Ministry tell us that the results of analyses in progress on the incidence of unconfirmed herd breakdowns in south west England suggest the majority (probably in excess of 80%) of such incidents were due to exposure to *M.bovis*. In the absence of completed analyses we are unable to make any judgement on this, but the issue is obviously very significant when forming a view on the success of the eradication policy. The number of new confirmed and unconfirmed herd breakdowns each year from 1976 to 1984 are shown separately in the following table. This indicates that well over half of all breakdowns remain unconfirmed.

New herd breakdowns from 1976 to 1984:—

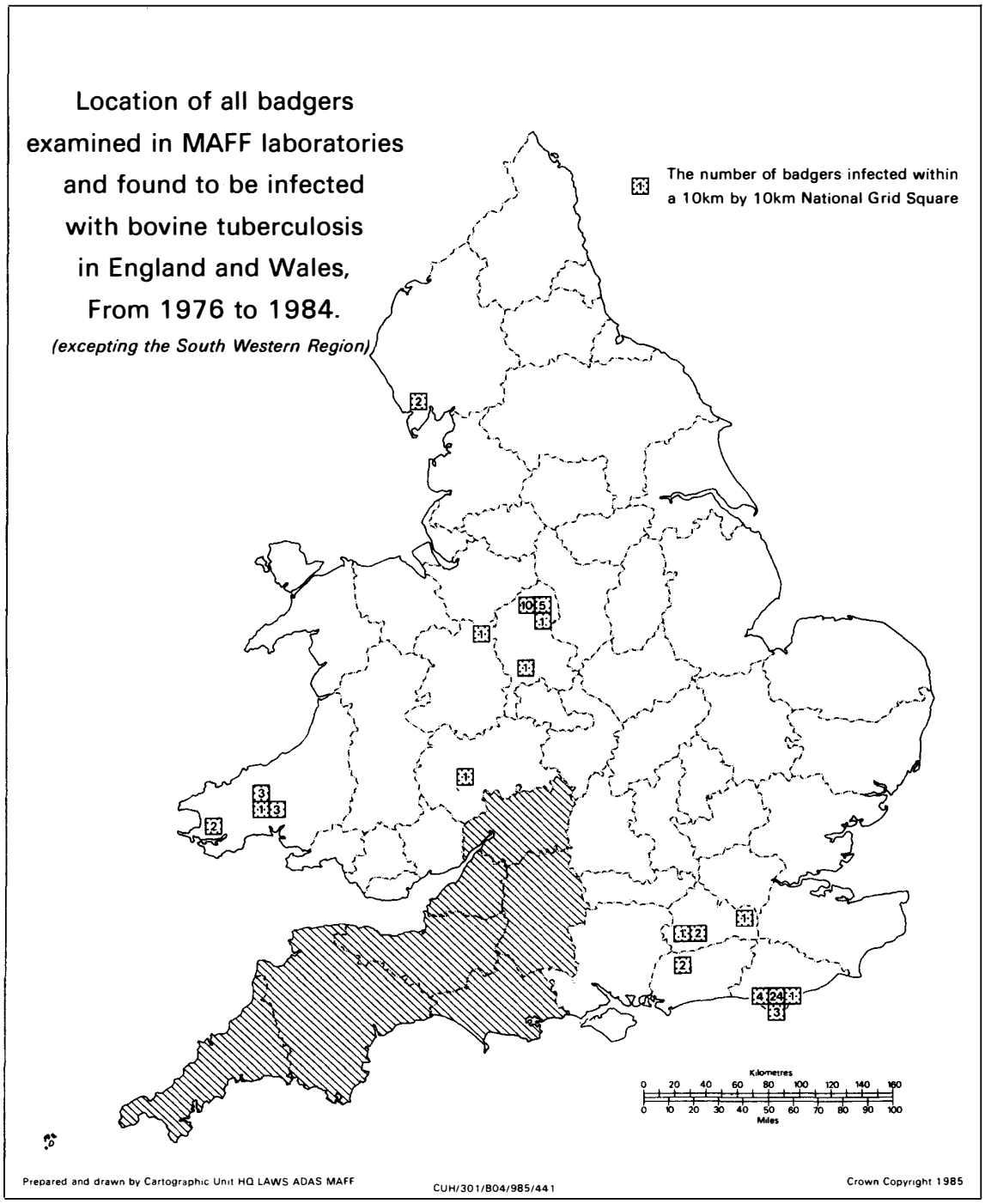
	1976	'77	'78	'79	'80	'81	'82	'83	'84	Total
England, Wales and Scotland (excluding south west region of England)										
Confirmed	40	37	22	31	28	25	31	18	20	252
Unconfirmed	41	55	39	31	61	44	50	59	80	460
Total	81	92	61	62	89	69	81	77	100	712
South west region of England										
Confirmed	108	73	62	58	88	108	82	75	70	724
Unconfirmed	137	108	72	56	112	80	64	85	112	826
Total	245	181	134	114	200	188	146	160	182	1550
Great Britain										
Confirmed	148	110	84	89	116	133	113	93	90	976
Unconfirmed	178	163	111	87	173	124	114	144	192	1286
Total	326	273	195	176	289	257	227	237	282	2262

33. The origins of infection attributed by the Ministry to all the confirmed herd breakdowns in Great Britain from 1972 (i.e. the year after the badger was first implicated as a reservoir of infection for cattle) to 1984 are shown in tabular form at Appendix 5. It can be seen that Irish cattle have been a significant source of infection, particularly in the early 1970s. However since 1976 Irish cattle have been subjected to pre-export testing in addition to the post-import testing measures which were taken already, and because there has been a reduction in the number of cattle imported from Ireland from some half a million in 1971 to less than thirty thousand in 1983, the number of herd breakdowns associated with Irish cattle has fallen significantly. Throughout the

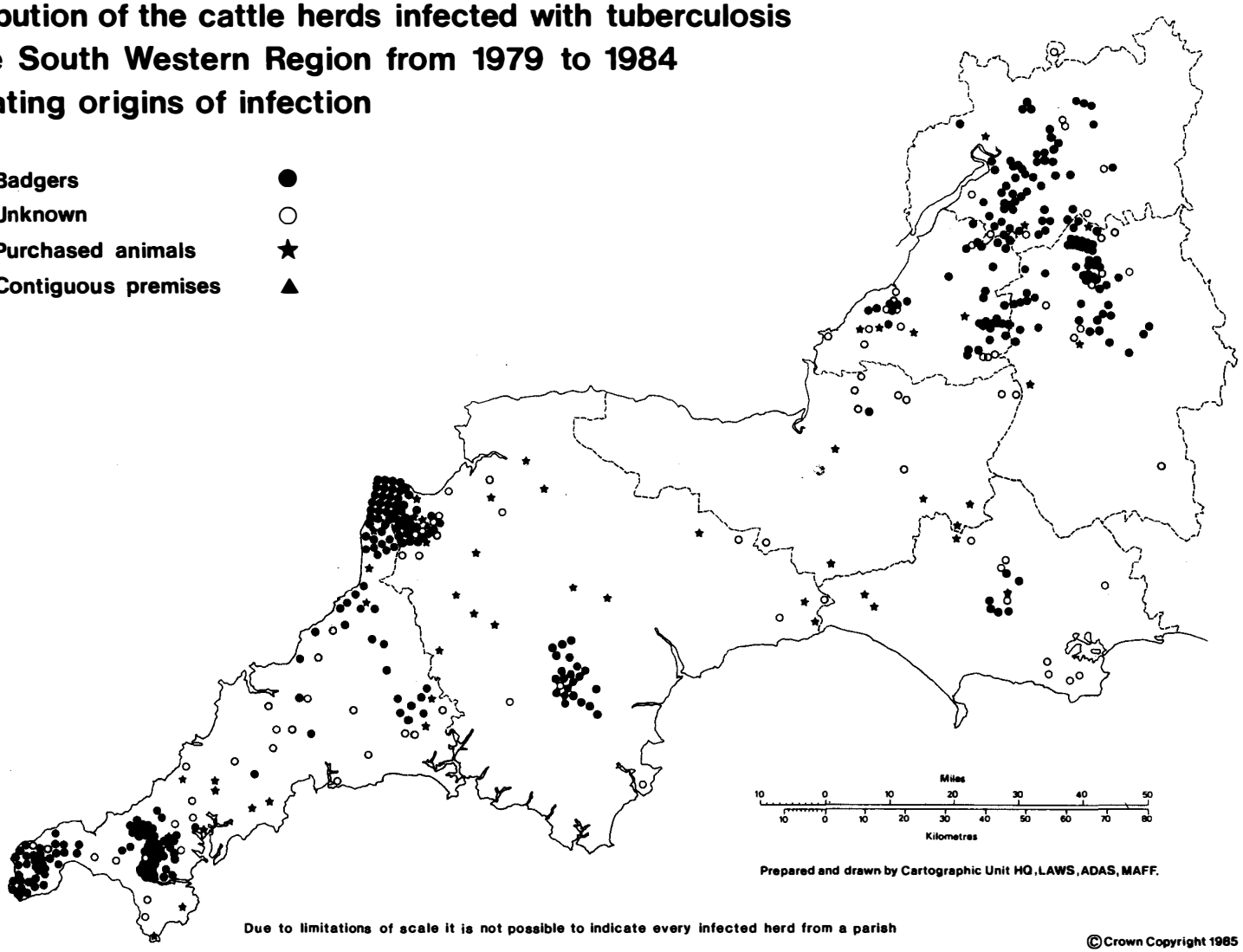


Due to limitations of scale it is not possible to indicate every infected herd from a parish

CUH 985/846


Location of all badgers examined in MAFF laboratories and found to be infected with bovine tuberculosis in England and Wales, From 1976 to 1984.
(excepting the South Western Region)
The number of badgers infected within a 10km by 10km National Grid Square
Kilometres
0 20 40 60 80 100 120 140 160
0 10 20 30 40 50 60 70 80 90 100
Miles
Prepared and drawn by Cartographic Unit HQ LAWS ADAS MAFF
CUH/301/804/985/441
Crown Copyright 1985

Distribution of the cattle herds infected with tuberculosis in the South Western Region from 1979 to 1984 indicating origins of infection



Due to limitations of scale it is not possible to indicate every infected herd from a parish

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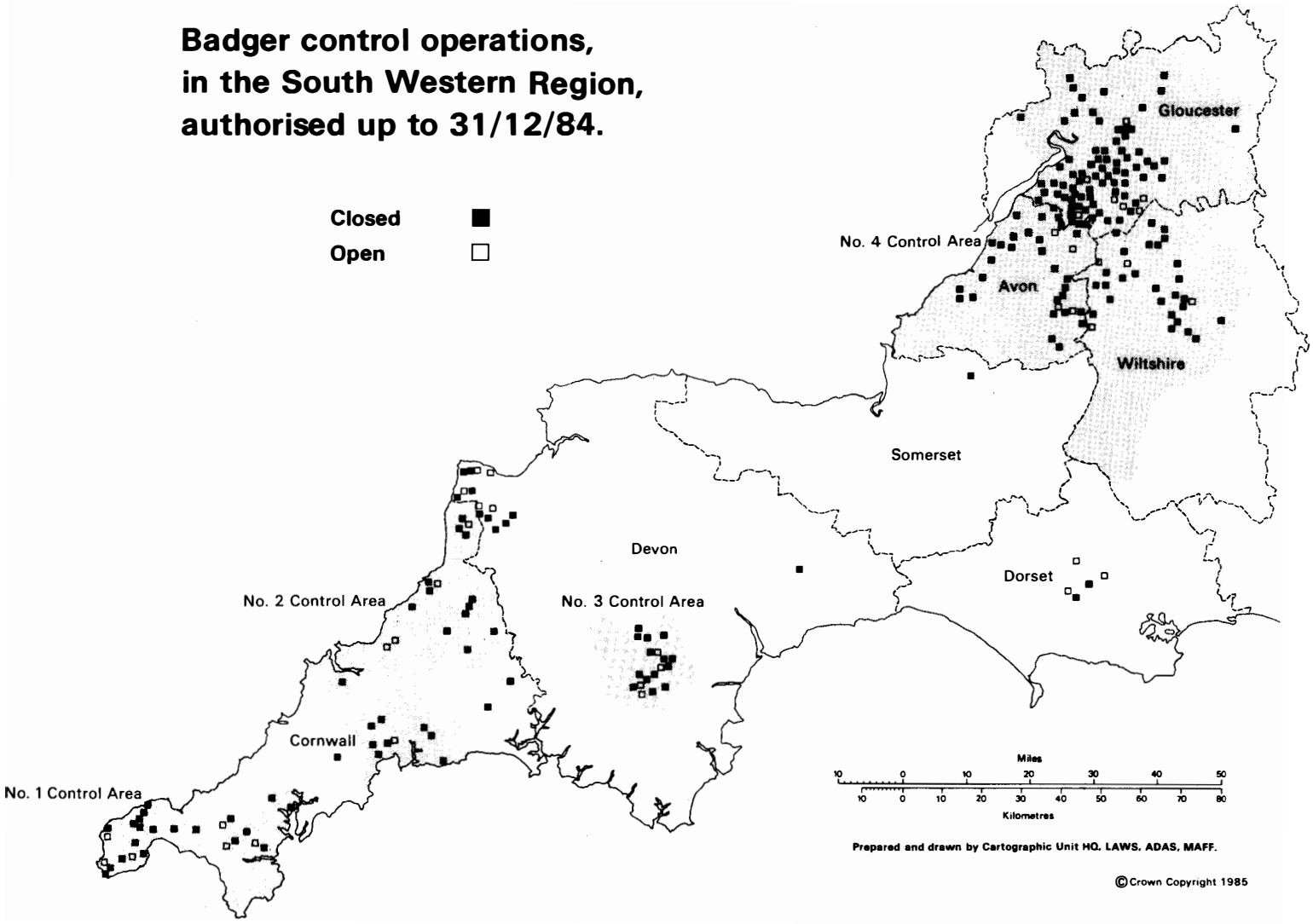

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period the geographical distribution of herds infected by Irish cattle has been confined almost entirely to Scotland and north east England. Over the last few years the origin of infection attributed to purchased home-bred cattle have accounted for 10% to 12% of confirmed breakdowns, whilst virtually no breakdowns have been attributed to contact with infected cattle on contiguous farms.

Incidence in badgers

34. In the absence of a diagnostic test for tuberculosis in living badgers and with an unmanaged population, the evidence on the distribution and incidence of bovine tuberculosis in badgers is derived mainly from badger removal operations, supplemented by examination of carcases from road casualties. The Ministry has provided us with two sets of data on the incidence of bovine tuberculosis in badgers and these are contained in Appendices 6 and 7. Appendix 6 shows the numbers of badger carcases examined following official Ministry investigations and, of those, the number from which *M.bovis* was isolated. This database thus includes all the badgers taken (a) as samples in preliminary badger investigations over the whole period from 1975 onwards, (b) in removals by live trapping and (c) in maintenance and monitoring phases by live trapping. Any interpretation of these data must take into account two important aspects. First, up to June 1982 most badger removal operations (including the maintenance phase) were undertaken by gassing, and the gassed badgers were not available for examination. Second, since June 1982 all badgers taken by live trapping, including the "clean ring" of social groups in removal operations, have been subject to examination; consequently a higher proportion of "clean" badgers will of necessity be included in those examined. What can be said is that these data suggest incidence levels in the region of 10% to 15%, and provide no evidence that the incidence of the disease in badgers is rising. All the official investigations will have been instigated by the discovery of disease in cattle, except for the rare occasions when investigations followed the discovery of an infected badger carcase. Appendix 7 shows the number of badgers examined, having died of causes other than being killed by the Ministry, and the number of these from which *M.bovis* was isolated. The majority of these badgers, mostly killed in road traffic accidents or dying naturally, were reported to the Ministry by members of the public. Such public participation (which must necessarily stop short of actually handling the badger carcases because of the risk of infection) is to be welcomed as a major means of adding to the knowledge of the incidence of disease in badgers.

35. We recognise that, for the most part, these data on the distribution and incidence of the disease in badgers have been obtained as a result of Ministry operations and may therefore be subject to some bias. Even the data shown in Appendix 7 may be biased in that public awareness of the Ministry's wish to be notified of badger carcases is likely to be greater in areas subject to control operations.

36. Because of the numbers involved it is difficult to show on a small scale map the detailed distribution of known infected badgers in south west England. However the map at page 11 shows the locations of the badger removal operations authorised there up to the end of 1984. The Ministry had undertaken some 400 preliminary badger investigations in the region up to that time. These investigations led to the authorisation of about 200 badger removal operations, with an additional 40 or so badger removal operations having been authorised without a specific prior investigation because an infected badger had been found independently of a herd breakdown.

37. Outside south west England, *M.bovis* has been isolated from badgers in Surrey, Sussex, Herefordshire, Shropshire, Staffordshire, Cumbria and Dyfed. Not all of these positive isolations (see map at page 9) have led to badger removal operations, either because there were no cattle at risk in the area or because there had been no recent herd breakdowns for which the origin of infection was unknown. In England, badger removal operations have taken place outside the south west in the Ipstones, Bradnop and Cheddleton parishes of Staffordshire; at Blawith in south Cumbria; and in the Folkington area of East Sussex. The operation in the Folkington area, which was started in 1984, was obstructed by groups protesting on the basis of "the animals' rights" but those in the other two counties have been completed. In addition to these areas preliminary badger investigations have been undertaken as a follow-up to herd breakdowns in other small areas of Sussex, south Cumbria, North Yorkshire, Staffordshire, Shropshire and Cheshire, either by sampling faeces or carcases, with negative results. As a result, no badger removal operations took place.

38. Outside south west England the most extensive area of official badger investigations has been Dyfed in south west Wales. *M.bovis* has been isolated from badgers in four areas in the county and badger removal operations followed in three of them. The badger removal operations which commenced in 1981 and 1982 at Walwyn's Castle and Conwil Elfed have been completed. The operation which commenced in 1981 at Trelech has been subject to extensions and has yet to be completed. In addition preliminary badger investigations have been undertaken at another eight sites in Dyfed either by sampling faeces or carcases, with negative results. Other investigations are still in progress. Elsewhere in Wales one preliminary badger investigation has been undertaken with negative results as a follow-up to a herd breakdown in Clwyd.

Incidence in wildlife other than badgers

39. In their investigations of herd breakdowns, Ministry officials have examined a number of wild animals other than badgers. In addition some other wild animal species have been subject to routine examinations for *M.bovis* after being submitted to Ministry laboratories. The results of all these examinations are summarised at Appendix 8. *M.bovis* has been found in a small number of rats, foxes, moles, mink and deer. These animals had all been caught or found in areas of south west England and Dyfed where tuberculosis had occurred in cattle and/or where cases of tuberculosis in badgers had been found. Microbiological studies of wild mammals in

Great Britain conducted by other organisations, albeit fairly limited in their scope, have also produced generally negative results as far as tuberculosis is concerned.

40. As a result of Lord Zuckerman's recommendation that wildlife other than badgers should be systematically sampled and examined for tuberculosis, the Ministry conducted an investigation of the potential role of other wildlife species in the spread of *M.bovis* in an area of known badger infection in East Sussex between 1981 and 1984. The numbers examined in this investigation are shown separately in Appendix 8 and no species other than the badger was found to be infected with *M.bovis*.

41. Of the wild species, other than badgers, from which the Ministry has isolated *M.bovis,* none has revealed actual lesions of tuberculosis on *post mortem* examination except for deer. It has been concluded that where visible lesions are absent infected animals are not likely to be infectious. However the confirmation of generalised tuberculosis in a roe deer (*Capreolus capreolus*) in 1984 from the same area of Wiltshire as an earlier case in 1980 has led to the Ministry conducting investigations to determine whether there is a reservoir of tuberculosis in deer in the south west. Samples taken from culled deer from selected areas of south west England have so far mostly proved negative but *M.bovis* has been isolated from three sika deer (*Cervus nippon*) and one roe deer, all from the Purbeck area of Dorset, in the period beyond that reported on in Appendix 8. Thus infection has now been confirmed in a total of six deer; all had visible lesions. Although the finding of tuberculosis in wild deer must give some cause for concern about the possible role of these species in the maintenance of the disease, it is most unlikely that wild deer would provide a significant risk for cattle.

42. It has been put to us that the statistical evidence to support an assumption of negligible levels of tuberculosis in wildlife, other than badgers, is poor. The argument goes that for species with very large populations, even a low overall level of disease incidence could nevertheless imply very large numbers of infected individuals in some areas which may then represent an important reservoir; and that such species have not been examined in sufficient numbers to satisfy statistical significance tests. To resolve this issue, very large numbers of each species would have to be killed over a wide area for detailed examination. We are reluctant to recommend this on ethical grounds, because of the laboratory and other resources that would be required, and because it seems unlikely that there would be a significant source of infection for cattle. Apart from the six deer there is at present no evidence that individuals of other wild mammalian species can become infectious and as a result transmit infection to cattle. We recommend that the Ministry should continue to take such opportunities as arise to examine other species, and particularly to continue with their initiative on deer. However, for the time being, we find insufficient evidence to convince us that badgers do not represent the primary potential wildlife reservoir of the disease.

Domestic species

43. The Ministry has given us the following overview to support the contention that tuberculosis in other domestic mammals has not posed a serious threat to cattle. Pigs have been found to be tuberculous occasionally, usually as a result of being fed milk from infected cows, but the disease did not establish itself in those pig herds and affected animals are unlikely to have been infectious. On rare occasions cases have been reported in horses, sheep and goats. Almost as infrequently the disease has been recorded in dogs and cats. In the dog, the infection was usually caused by *M.tuberculosis* from humans while in the cat it was usually due to *M.bovis* from cow's milk.

44. The involvement of other domestic species is considered automatically in the veterinary investigation into the source of infection following a herd breakdown. In the past both goats and pigs have been implicated as a source of infection for cattle. Usually such an infection had been acquired originally from cattle. The Ministry considers tuberculin testing of goats or pigs only if infection in cattle is confirmed on the farm or in the vicinity. Infection in dogs and cats has been reported concurrently with infection in cattle, but neither species has been identified as a reservoir for re-infection of cattle. It is only in the case of recurring herd breakdowns on farms that cats and dogs might be implicated but recurring infection in cattle accounts for a small proportion of cases (less than 6% of herd breakdowns between 1972 and 1978 were of a recurring nature). If infection were common in either species we would expect local veterinary practices to have identified it in the course of their day to day work and it would then be reported following *post mortem* examinations. Since the tuberculin test in dogs and cats is considered to be unreliable, in all situtations where there are suggestions that these animals might be involved in a herd breakdown, with the owner's consent a battery of clinical, serological, cultural and other tests may be used in an attempt to come to a diagnosis. Because they are uncontrolled, there is always a possibility that feral cats might occasionally be a source of infection but we consider this unlikely and there is no evidence to support such a theory. As far as other domestic species are concerned, investigations as to whether they might be a possible source of a herd breakdown are made only if the animals show clinical signs suggestive of tuberculosis, or if local epidemiological evidence suggested that such an investigation might be useful. Since sheep and pigs are normally slaughtered for meat, any significant occurence of infection in these species would be apparent and reported as a result of the statutory meat inspection regime. We accept that, on the basis of the evidence available, other domestic species do not represent a significant source of tuberculosis for cattle.

Other countries

45. Before leaving this description of the distribution and incidence of bovine tuberculosis we consider that it is relevant to consider the role of tuberculosis in cattle and wildlife in other countries. Information on this subject is very limited and we have been unable to judge in all the reported cases whether such wildlife reservoirs of the disease are a threat to cattle populations. A considerable number of factors can affect the level of the

disease in a national herd as well as in a wildlife reservoir. For example the Department of Agriculture for Northern Ireland acknowledged to us their belief that infected badgers play a part in the transmission of the disease to cattle there (*M.bovis* has been isolated from about 10% of over 450 badgers examined in Northern Ireland since 1977). However the transmission of the disease following the uncontrolled movements of infected cattle is seen as a more significant problem there, where the incidence of tuberculosis in cattle is about twice as high as that in south west England. The authorities there are tackling that problem first before considering the role of the badger. Tuberculosis in cattle is even more of a problem in the Republic of Ireland, where the incidence of disease in cattle is some eight times as high as in south west England. *M.bovis* has been isolated from badgers, fallow deer (*Dama dama*), red deer (*Cervus elaphus*) and sika deer there and we understand that badgers and deer have been the subject of investigations into the source of infection in herd breakdowns.

46. In New Zealand the introduced wild brush-tailed possum (*Trichosurus vulpecula*) is regarded as a significant reservoir of *M.bovis* for cattle. Action to control the disease has been instigated, largely to reduce the overall population of possums in affected areas where the cost/benefit assessment justifies such action. *M.bovis* has been isolated from a number of species in New Zealand but only infected wild deer and feral pigs, other than possums, are thought to be of any significance in maintaining a reservoir of the disease; they can act as vectors for the transmission of tuberculosis between groups of possums, rather than provide a direct source of infection for cattle. In Australia investigations are being undertaken in the Northern Territory to determine the risk to cattle of a reservoir of infection identified in the feral water buffalo (*Bubalus bubalus*). A number of other examples of wildlife species being infected in various countries have been drawn to our attention. Evidence of tuberculosis in badgers was recorded in Switzerland in the 1960s, but we understand that on that occasion infected roe deer rather than badgers were considered to pose a greater threat of transmission of the disease to cattle.

47. In conducting this review we have been mindful of the disease situations, and the action taken, elsewhere in the world. However, the situation in each country will be different and no exact parallels can be drawn with the position in Britain.

CHAPTER 4

DIFFERING VIEWS ON THE PROBLEM

Views expressed on the badger control strategy

48. The Ministry's policy on bovine tuberculosis and badgers and their strategy for its implementation are the subject of varied, and, in some cases, strongly held emotional views. Having received written and oral evidence from those listed at Appendix 13, we are clear that there is no single solution to the problem which would meet the wishes of all concerned. Although we recognise that even within the different groupings and organisations there is not a uniformity of view, for descriptive purposes we summarise the main thrusts of the conflicting views as follows.

49. The veterinary profession accept that badgers can and do contract bovine tuberculosis which they can then transmit to cattle. The veterinarians' view that badgers are the prime remaining reservoir of bovine tuberculosis from which cattle herds become reinfected. Therefore the central objective of the policy must be to remove those reservoirs that they believe persist in the badger population in certain parts of the country in order to prevent transmission of the disease to cattle. They draw an analogy between the removal of infected and contigous badger social groups, and the slaughtering of reactor cattle and cattle in dangerous contact with those reactors. They see no practical alternative to such action in the current state of knowledge, but support research which might lead to an alternative policy.

50. Farmers, particularly specialist dairy farmers, are, of course, the group whose livelihood may be affected most directly by this problem. In the event of a herd breakdown they do receive partial compensation from the State for the value of slaughtered cattle. But they have to bear financial losses in addition as a result of movement restrictions and the disruption of livestock production and herd management. There is also a slight health risk for their families and farm workers. Even for those who do not suffer herd breakdowns, there may be an additional burden of work and disruption if tuberculin testing in their area is more frequent than the norm. In such circumstances it is natural that the majority of, although not all, farmers support the continuation of the current policy until any alternative is available which would provide them with at least equivalent protection.

51. Most professional and many amateur conservationists who have considered this problem seriously, accept that badgers contract bovine tuberculosis and can transmit it to cattle. However they do not necessarily share the veterinarians' view of the significance of the role which infected badgers play in the overall epidemiology of the disease in cattle, nor do they accept that the objective of eradicating the disease from cattle over-rides wildlife considerations. They accept that, at the moment, it is necessary to kill infected badgers where there is a *prima facie* case that the badgers caused a herd breakdown, but naturally wish to minimise the number of badgers killed. Consequently, they question the current strategy of removing badger social groups contiguous to those found to be infected (i.e. the so-called "clean ring" approach), and strongly advocate research into techniques which may lead to alternative strategies. In general, they acknowledge that removal operations do not pose a serious threat to the badger population as a whole, and argue that there is no evidence to suggest that the disease is a threat to the badger population.

52. We found little argument amongst the animal rights groups against the contention that some badgers contract bovine tuberculosis, but they are reluctant to accept that the disease can be transmitted to cattle. They consider that the national incidence of the disease in cattle, and the infection rate in badgers, is so low that no killing of badgers is warranted. They claim that the current strategy of badger removal poses a severe threat to the national population of badgers and suggest alternatives such as the vaccination of badgers and/or cattle, and paying farmers more compensation for herd breakdowns.

Media attention

53. The controversies associated with the problem of bovine tuberculosis and badgers have been a fertile area for media attention. We feel bound to say, after reading a great many press cuttings on this subject going back over ten years, that the media have concentrated largely on the emotive aspects of the policy and have done little to further any balanced discussion. This has led in turn to the public gaining a biased view of the problem and the ways of trying to solve it.

The Ministry's response

54. The Ministry's response to the difficulties presented by such public reactions has been understandably defensive, but we believe perhaps too protective in the circumstances. However its response is to be seen in the creation of the Consultative Panel on Badgers and Tuberculosis, the series of public reports entitled "Bovine Tuberculosis in Badgers" and the liaison arrangements with the County Naturalists' Trusts in the counties most affected by the problem.

PART II – APPRAISAL

CHAPTER 5

CONSIDERATION OF THE CONCEPTUAL BASIS OF THE CURRENT POLICY AND STRATEGY

55. The present policy and strategy on bovine tuberculosis and badgers is based on a number of important premises which are discussed in detail in this chapter.

Transmission of disease from badgers to cattle

56. The evidence is unchallengeable that badgers can be infected by *M.bovis*, and can become infectious, i.e. they can discharge bacteria from open lesions into the environment, particularly from the urinary tract, but also from the intestine and the lungs. A limited experiment has demonstrated that infectious badgers can transmit the disease to cattle, although this experiment is often criticised for having been very "unnatural". The evidence for the transmission of bovine tuberculosis from badgers to cattle under field conditions is frequently described as "circumstantial", and relies on the probability of live bacteria discharged by badgers being encountered and inhaled or ingested by cattle. It has been shown that badgers can deposit large quantities of tubercle bacilli in their urine, and that they urinate frequently on pastures which are often used by cattle. Such pastures are often favoured by badgers feeding on earthworms coming to the surface and in a relatively short period large quantities of urine can be passed reflecting the high water content of the worms. What has not been shown definitively is that the disease in a particular herd has resulted from identifiable bacteria discharged by identifiable badgers on that particular patch of pasture. To demonstrate this with full scientific rigour would require extensive, long-term field studies, involving the killing of large numbers of badgers and cattle over an extensive area with substantial supportive laboratory services. In our view, this would not be justified on economic or ethical grounds. Even if advanced laboratory procedures, which are being developed at the present time, could identify specific forms of DNA in the bacterial cell and thus confirm that precisely the same strain of *M.bovis* was present in both cattle and badgers at the same place and at the same time, this would still not be final and conclusive proof for the transfer of the disease from badger to cow. It is important to recognise that inferential evidence is commonly accepted in relation to the transfer of many diseases from one host to another; influenza and foot-and-mouth disease being good examples. We believe that it is not necessary, and would be a waste of resources, to seek further confirmation for the transmission of tuberculosis from badgers to cattle.

57. There can be substantial time lags between a cow becoming infected and showing up as a reactor. This delay has two components: first, the time from initial infection to the development of an immune response which can be detected by the test; and second, the timing of the tuberculin test of the herd, which may be as much as three years later – although in areas of known infection tuberculin testing is annual. Following the discovery of a reactor cow, checks on local badgers, including the time taken for diagnosis of the disease in infected individuals, usually require a further six to nine months, and occasionally up to eighteen months. The longer the delay, the less the confidence in identifying a particular group of badgers as the source of the original breakdown.

58. We believe that infectious badgers are potential sources of infection to cattle and thus badgers must be taken into account when considering the policy of the eradication of bovine tuberculosis in cattle to which the Government is committed, not only as a national policy but also under the relevant EC Directive. Clearly an uninhibited disease eradication programme could involve the complete elimination of badgers in areas where the disease is prevalent. However, there are strong sustainable arguments in the context of nature conservation, public amenity and ethics which render such an approach unacceptable. As a result, a much more restricted approach to badger control has been adopted by the Ministry and this compromise itself has been the subject of considerable debate.

The badger as the prime reservoir of disease

59. Other species of wildlife have been considered unimportant as a source of tuberculosis for cattle. We have discussed this issue in paragraphs 39 to 42, and given the available data at Appendix 8. Even when infection does occur in these species there is no evidence that, with the exception of deer, they develop open lesions and become potentially infectious. We accept that for practical purposes other wildlife species can be disregarded, at least for the time being, as significant sources of infection for cattle. We would emphasise further that even if some species could provide a reservoir of infection, that would not in our view enable the Ministry to disregard the significant role of the badger which we consider to be proven.

Transmission of disease from cattle to badgers

60. It is assumed that transmission of the tubercle bacilli from cattle to badgers is very infrequent. Prior to 1950, cattle with open lesions were found frequently, but now, as a result of regular testing, open cases are so rare as to be insignificant as a source of infection to badgers. Where such cases do occur in cattle the infection is usually pulmonary, and very close contact is required for aerosol transmission. The organism is not excreted by cattle onto pasture in urine or faeces. The pulmonary route of transmission is more likely to affect other cows, rather than passing infection from cow to badger. We accept this premise.

Distribution of disease in badgers

61. The pattern of distribution of the disease amongst badgers is very little understood. It is assumed that tuberculosis in the badger population is a self-sustaining disease, and therefore poses a continuing source of infection to cattle. We accept this general interpretation, though we are not certain that it would apply throughout the country. It is generally assumed that the disease in the badger is found in local "pockets" rather than being spread uniformly through the population. We have discussed this point extensively with those who have given evidence, and inevitably we have found a variety of views. It appears that the pockets are not equated with individual social groups of badgers, but may involve a number of contiguous groups. The badger population is distributed over the countryside in social groups based on setts. These groups are relatively small (five to ten individuals) and in an undisturbed situation remain remarkably stable with an infrequent exchange of individuals between them. Each social group has its own territory demarcated by latrines, in which the badgers defaecate and scent-mark to establish boundaries. Transmission of the disease between one group and the next will be slow, and is likely to result only from (a) wounds inflicted by rival badgers at, or sometimes inside, territorial boundaries, (b) the ingestion of bacteria from the latrine area on these boundaries, and (c) the occasional movement of individual infected badgers which may establish themselves in an adjacent group. There may also be important, as yet unknown, seasonal and social patterns in such movements which may assist the spread of the disease in the badger population. As with tuberculosis in other species, it is to be expected that a high proportion of the animals in affected social groups will develop immunity to the organism; data from the Ministry show that in most affected groups only about 25% to 30% of the badgers are actually infected.

62. Apart from carcases reported by the public, badgers infected with tuberculosis are usually detected only after there has been a herd breakdown in cattle, and a preliminary badger investigation instituted. The assumption is that these badgers are part of a local focus of infection and the strategy then leads to the removal of infected social groups and all neighbouring groups until a ring of uninfected social groups has been eliminated. No further culling is then carried out beyond that so-called "clean ring". This whole approach and the data it creates may well reinforce the starting presumption that the disease is patchily distributed in badgers. In our view, the evidence for discrete pockets of infection surrounded by large areas where there is no infection is very poor, and it seems just as likely that the disease is widely but sparsely and unevenly distributed throughout badger populations. It seems quite probable that infection in badgers outside south west England is far more common than is currently assumed, but due to low badger density or relatively low cattle density, or other factors unfavourable to disease transmission, this fact is not manifested by herd breakdowns. This is the view also taken by epidemiologists, and is supported by the continued detection of infected badgers among those killed on the road, in various parts of England and Wales. The "pocket" theory is fundamental to the relevance of the present control strategy, and it is desirable that reliable information be obtained about the wider pattern of distribution of the disease in badgers. This would almost inevitably lead to the need to sample badgers in areas in which there are currently no herd breakdowns. This requirement is considered further in chapter 9.

63. Related to the "clean ring" hypothesis is the presumption that the cleared area will be recolonised by uninfected badgers. It is difficult to obtain data to check this assumption, because those badgers which are caught during the maintenance period after a badger removal operation may be either resident animals which were missed earlier on in the operation, immediate neighbours or new immigrants. Illustrative data on the infection rates of badgers examined in connection with the separate phases of Ministry operations are detailed at Appendix 9, and suggest infection rates of 10% to 15% in badgers taken in the removal phase and amongst the recolonising individuals. As we have indicated previously in the report, some care must be taken in interpreting the data on the removal phase of operations as the measured infection rate in most completed cases will be lowered by the inclusion of the uninfected social groups forming the "clean ring"; the only exceptions are the cases which had been completed on reaching an area of no badger activity. Having said that, it remains the case that the infection rates in the maintenance phase, particularly in Avon and Gloucester, do not support the presumption that cleared areas will be recolonised by uninfected badgers.

64. A further problem with the procedures which lead to the elimination of a "clean ring", is that this removes a buffer zone to an area of infection, and the considerable disturbance then leads to instability in the badger population, with animals wandering over greater distances into cleared territories and perhaps as a result bringing a new focus of infection with them.

CHAPTER 6

OPERATIONAL ASPECTS OF CURRENT STRATEGY

A. CATTLE

65. We turn now to an appraisal of operational aspects which may have affected the success of the Ministry's strategy on bovine tuberculosis and badgers. Before dealing with aspects relating directly to the badger operations we touch on issues associated with the wider programme for the eradication of bovine tuberculosis in cattle. In remarking on these potential deficiencies we would emphasis that they do not affect the central thrust of any strategy on bovine tuberculosis and badgers, but nonetheless they merit some comment.

Identification of infection in cattle

66. As we have indicated earlier in the report, the tuberculin test is the best currently available method of identifying infection in cattle but it cannot be regarded as completely reliable; it requires the injections of tuberculin to be accurately located intradermally, and subsequent examination and interpretation, in a variety of farm situations. However, it is clearly important that there should be no slippage in the programmed frequency of routine tuberculin testing if the risk of infected cattle remaining undetected is to be reduced. The laboratory examination of tissues from reactor cattle provides a back-up to the testing system. However we recognise that the techniques required to isolate and identify *M.bovis,* which are of particular importance in those animals which have no visible lesions *post mortem,* are very elaborate and only samples of the animals can be examined. All these factors will reduce to some extent the number of infected cattle which are identified as carrying tuberculosis.

Transmission of disease between cattle

67. It has been put to us that the unrecorded movement of infected cattle from one farm to another might play a significant role in the transmission and dispersal of the disease. We agree that undoubtedly cattle are moved without the legally required record of movement being kept, especially where movements are local. However if this had a large scale impact it would soon be recognised when purchased cattle were identified as infected but could not be traced to a herd of origin. This has not been the case in recent investigations into herd breakdowns.

68. We are also aware of recent studies in Northern Ireland which imply that routine *post mortem* examination of cattle may not reveal the full number which have tuberculous lesions in the lungs or which simply have *M.bovis* in the respiratory tract. If this situation pertains throughout Britain it may be that there is more transmission of the disease from one bovine to another than is currently recognised. However the results of check testing herds contiguous to a breakdown herd indicate that the disease is rarely transmitted to neighbouring herds, so this finding seems likely to be significant only in the context of transmission between animals within a herd. The Ministry has long recognised that not all carriers of *M.bovis* will be identified at *post mortem* examination.

B. BADGERS

69. For the most part, badger operations commence only when infection has first been identified in cattle. We now comment on aspects directly relating to those badger operations.

Delineation of badger social groups

70. The current strategies for badger investigation and removal operations require the delineation of the territories of badger social groups. As we have explained badgers demarcate such territories by use of latrines at the territory boundaries. The primary method used by Ministry operators to delineate the social group territories is to place coloured plastic chips in a palatable soft food at sett entrances, using a different colour at each main sett, and then to record the latrines in which markers of a particular colour are found in the faeces. The success of this method has to assume that the Ministry's operators find all the setts in a surveyed area. There must be some doubt that they can always achieve this target, particularly in areas of difficult terrain such as thick woodland, undergrowth, bracken, cliffs and mine shafts. We believe that in the circumstances it is unlikely that all the setts in all the areas surveyed will be found, and that further improvement would come only with a far greater commitment of manpower resources. An additional problem is that badgers' territorial behaviour is at a peak only during the spring and for a short period in the autumn, as the research at the Ministry's Gloucestershire study area has shown. If bait marking were limited to these periods of the year in order to maximise returns from the procedure, many investigations would be subject to delay. If investigations proceeded outside these periods the results of the bait marking may not provide clear evidence of the territorial boundaries.

Identification of infection in badgers

71. Having made a judgment on the territories of individual badger social groups, the next practical problem is to discover whether the badgers are infected. At present there is no diagnostic test for *M.bovis* in living badgers. Attempts to culture *M.bovis* from the faeces of badger groups suspected of having tuberculosis have been made with varying success, but this has not proved to be a reliable indicator of infection in operational conditions. The technique has severe limitations in terms of the requirement for fresh samples, its labour

intensive nature, the intermittent excretion of the organism, the fact that there may be very few organisms excreted in faeces, and the difficulty of interpreting results. In any event the technique is only of use in detecting badgers which are excreting *M.bovis* in their faeces, rather than in urine or sputum. Clinical sampling of badgers has been undertaken at the Gloucestershire study area. This involves the taking of samples of faeces, urine, a tracheal aspirate and blood for serology, together, where appropriate, with swabs from bite wounds or ruptured lymph nodes or abscesses. Even detailed sampling like this has limitations, as it can only detect *infectious* badgers or those with clinically obvious lesions of tuberculosis. The method has enabled valuable data to be collected for research purposes, but it would be impractical and unreliable to use as an accurate diagnostic tool for routine operations.

72. Where it is necessary to check whether or not badgers are infected (i.e. strategies A and B) the operational method employed in almost all circumstances to identify infection in badgers is to trap and kill two badgers from each social group in the area under investigation for *post mortem* and laboratory examination of tissues and fluids. We recognise the dilemma inherent in sampling at a level necessary to give a reasonable probability of detecting any disease present without threatening the viability of the social group. The fact remains that, on purely statistical grounds, there are doubts about the merit of the sampling scheme used by the Ministry. Evidence from the Ministry's laboratory examination of all badgers (i.e. from official investigations and road traffic accidents, etc.) from south west England over the period from 1972 to 1984 indicates an infection level of about 10%. The statistical doubts about the sampling scheme are highlighted by the following hypothetical examples, which assume a uniform infection rate of 10% in the badger population. If a sample of 2 badgers were taken from a single social group containing 8 badgers, the probability of finding at least one infected badger would be about 0·20. By sampling three social groups of this size, the probability of finding an infected badger would increase to about 0·51. However in reality the infection level in badgers is not uniform; some social groups have no infection, while there is evidence to suggest that the average level of infection in infected social groups may be 25% or more. Using an infection rate of 25% throughout the three social groups in our second hypothetical example, the probability of finding an infected badger in a sample of six would increase to 0·86. This last example may be closer to what happens practically in badger operations, although it would not necessarily be the case that three contiguous groups would each contain infected badgers. If only one of the groups was infected (at the 25% level), the probability of finding an infected badger among the six would be 0·46.

73. It is clear that in many cases the current sampling arrangements will fail to find infection even though it is present in the badger social groups sampled. With a disease level of 25% in infected badger populations, a sample of 3 or 4 badgers from a social group of 8 would be required if the chances of successfully identifying the presence of the disease were to be 7 in 10. The necessary sample size rises to 5 badgers if odds of 9 out of 10 were sought. If infection levels are lower than this, even higher sampling rates would be necessary to permit reasonable certainty of identifying infection in social groups. The Ministry has avoided this problem to an extent by an increased use of strategy C (see Appendix 3), which involves no prior sampling, for badger removal operations.

74. When the sample of badgers has been caught, infection is confirmed by the presence of visible lesions in the carcase and/or the isolation of *M.bovis* from one or more tissues or body fluids. The techiques for growing Mycobacteria are now well established but are lengthy and involved, with some species and strains being more difficult to culture than others. *Mycobacterium bovis* can now be grown reasonably reliably in the laboratory and the technology is becoming available to identify particular strains accurately on the basis of their DNA, the antigenic structure of the bacterial cell and the immunological response it produces to "in vitro" testing. Although some infected animals will not be found because of all the practical problems involved in examining carcases and tissue samples, which we have already outlined, by far the majority will be identified.

75. These points may be illustrated by reference to the records for the 11,733 badgers examined by the Ministry from all sources in the south west between 1972 and 1984 inclusive; 9·6% of these were found to be carrying *M.bovis* but only 4·3% had visible lesions (see Appendix 10). This shows the importance of carrying out laboratory culture of tissues and fluids even when no visible lesions are seen on gross examination of the animal. It is noteworthy that laboratory examination fails to isolate *M.bovis* from visible lesions in badger carcases in a higher percentage of cases from Devon and Cornwall than elsewhere in the south west. There is no obvious explanation for this unless it is an indication of slight variations in techniques employed in different laboratories.

Capturing all badgers

76. If infection has been identified in badgers the problem then is to capture all badgers in the social groups to be removed in the operation. Although most badgers can be trapped readily (indeed some badgers at the Gloucestershire study area are trapped repeatedly for clinical sampling) there are practical difficulties with trap-shy badgers and in laying traps in some terrains. Even when free-running snares are used as a back-up to trapping we believe that some badgers escape or avoid capture. Further seasonal variations in badger activity will affect the effectiveness of live trapping.

Release of lactating female badgers

77. An additional constraint on successful total removal of infected badgers is the practice of releasing any lactating female captured. The Ministry operators are instructed to check for lactating female badgers, especially in the period from February to April. It is difficult for the operators to recognise whether a badger in a cage trap (snares are not used during this period) is lactating or not, as badger mammary glands are small.

Data provided by the Ministry indicate that one fifth of all adult female badgers killed during the lactation season by Ministry operators are lactating – similar to the proportion killed on the roads. The *post mortem* records do not differentiate between the stages of lactation and thus how dependent cubs might have been on the lactating female. However the success of the operation must be impaired if any infected badger is released, and lactating females, if infected, may well transmit the disease to their cubs through their very close relationship with them.

Mobility of badgers

78. The mobility of badgers has considerable implications for the removal phase of operations if sampling has disturbed the social groups, and for the maintenance phase, in which any practical regime of follow-up visits may not keep the area clear for the period in which live bacilli might remain in the setts. Research at the Gloucestershire study area, where the badger population is dense and relatively stable, has shown that (a) the territorial boundaries of badger social groups remain stable from year to year provided there is no external interference, (b) only a very small proportion of badgers move permanently away from their parental group and (c) recolonisation of cleared areas can take of the order of seven years to reach the estimated carrying capacity. However in contrast to this picture of general stability, the research has also shown that movements do occur including occasional forays into adjoining territories, movements between neighbouring groups and movements induced by disturbance. These temporary movements, observed from 1976 to 1985, relate to about 28% of the badgers in the study area. There is also evidence that some badgers infected with bovine tuberculosis display a typical behaviour by ranging over several territories, living a largely solitary existence and sometimes occupying farm buildings. Although it may take years for badgers to become fully re-established in a cleared area, some may move in within a few days. Data from badger removal operations starting in a selected period in 1984 and 1985 indicate that there were signs of badger activity in over 50% of the operations during the six month maintenance phase. As indicated in paragraph 63, such badgers could be resident animals which were missed earlier on in the operations as well as new immigrants.

Duration of badger operations

79. Our general impression is that the current strategy can involve operations extending over an inordinately long period. We have already touched on the delays that may occur from the time of the transmission of infection from badgers to cattle, through the subsequent identification of that infection in cattle to the point when, after investigation for other possible sources of infection, it is recognised that a badger investigation needs to be mounted. The badger investigation could then be delayed further until the optimal periods for delineating social group territories. After the animals are trapped there is a wait of 6 to 8 weeks while laboratory confirmation of infection is awaited if gross lesions of tuberculosis are not evident at *post mortem*. The timescale of operations obviously depends on all of these factors and on the number of social groups which have to be taken before a "clean ring" is removed. The successful completion of a control scheme has been complicated further in practice by operations being extended due to further herd breakdowns, the continuing overlap with operations originally begun in the gassing era, and severe local staffing shortages at some times. Although these last mentioned factors will have influenced the data, the Ministry calculates that in south west England in 1984 the average period from a badger investigation being requested to the completion of a badger removal operation (including the 6 month maintenance phase) was about 25 months. During any delay in badger operations, the risk of the transmission of the disease from badgers to cattle is not reduced and the implications referred to at paragraph 57 come into play.

80. Throughout much of these lengthy badger operations, the activities of the Ministry operators are vulnerable to individuals and groups who exhibit their opposition to the strategy to the extent of physical interference. Such action has both a detrimental practical and psychological effect on the operators and will inevitably extend the period of operations even further.

Ministry operators

81. In commenting on these aspects of the badger operations which may have hindered the success of the strategy, we recognise that the Ministry has had to deal with an extremely difficult problem. In the field the operators have had to contend with tough, physical working conditions. As well as direct interference they have had to endure a general lack of public regard and support for their work given the picture painted of it by the media. There have been difficulties also with their conditions of service in (a) having to work unsocial hours for which time off in lieu is generally allowed rather than overtime being paid, and (b) having to tolerate a lack of job security given the fixed-term appointments which were made until recently. We must emphasise that we make no criticism of the Ministry's operators. We believe that they have undertaken the task in a humane and practical manner and have certainly not taken indiscriminate action against badgers. The strategy, by its very nature, requires a cadre of dedicated and skilled operators receiving a high level of training, supervision and remuneration. The strategy also requires an adequate level of resources both in terms of manpower and equipment. This has not always been easily achieved.

CHAPTER 7

HAS THE BADGER CONTROL STRATEGY SUCCEEDED?

82. We consider the success of the badger control strategy in terms of (a) the impact it has had on the incidence of bovine tuberculosis in cattle, and (b) the economic cost to the nation.

Has the incidence of disease in cattle been affected?

83. Although bovine tuberculosis was first diagnosed in a badger in Great Britain in 1971, it is likely that badgers were infected at a much earlier date when there was a higher incidence of disease in cattle and when many more cattle were infectious and excreting organisms for badgers to pick up. Whether cattle or badgers first infected the other is immaterial at this stage. What is relevant is that we assume badgers were infected with bovine tuberculosis for at least the period since 1962 as covered in Appendix 4. Thus our interpretation of the data is on the basis that there has been no new role for badgers in the epidemiology of the disease during that period.

84. Evidence of the effectiveness of the strategy might be sought through an examination of changes in the number of herds with reactors in areas subject to badger control operations. Our preference for using reactor herds rather than the total number of reactor cattle to measure disease incidence is explained in Chapter 3. A major problem in examining these data is that there can be no formal comparison with areas not subject to badger control, as none were left deliberately undisturbed. Broad comparisons can be made using the graphs in Appendix 4 showing the trend in the level of herd breakdowns in south west England (taken as being subject to badger control) and the rest of England and Wales (taken as being not subject to badger control). Following the declaration of national attestation in 1960 (see paragraph 6) there was a continuing marked decline in the incidence of the disease in cattle nationwide, due largely to the programme of slaughtering reactor cattle. This decline began to level off from about the mid-1960's. The Ministry commenced badger control in 1975 and in the same year changed the tuberculin test in cattle to improve its specificity. There is no easy way of disaggregating the separate impacts of these two events on the incidence of reactor herds in south west England. However, given that the problem areas of the south west were subject to annual testing, we would expect the change in the tuberculin test to show over, say, a two-year period, a single step reduction in the trend of herd breakdowns. In contrast, if badger control was effective in reducing the incidence of disease in cattle, and allowing for the moratorium on gassing in new areas when Lord Zuckerman conducted his review, herd breakdowns would show a marked continuing decline. Although the graph shows some indication of a decline in overall incidence it does not suggest that complete eradication is an attainable goal with the current strategy.

85. We conducted a formal statistical analysis on the time series of herd breakdowns from 1963 to 1984 in an attempt to identify the underlying trend and whether any discernible change had taken place since badger control operations commenced. Statistical trend models were fitted separately to the data for south west England and for England and Wales excluding the south west, the full details being reported in Appendix 11. In a statistical sense the results were regarded as most satisfactory. The incidence of herd breakdowns outside the control areas of the south west shows a constant decline at the rate of about 7% annually until the mid-1970's. A sharp reduction in incidence took place at that time, probably due to the improved tuberculin test and the control of cattle imports from Ireland, since when the annual rate of breakdowns has remained steady at about 8 per 10,000 herds. By contrast, there was no evidence of a similar decline in incidence in south west England. Herd breakdowns fluctuated around a mean level of some 160 per 10,000 herds up until 1975/76 when a marked drop took place, and since then have varied around a mean of just over 90 per 10,000 herds. Both regions, therefore, portray a break in the series in the mid-1970's, and the explanation advanced for this in the south west is criticial to any judgement of the success of badger control. Irish imports were not a significant factor in this region, but some of the observed effect might be attributed to the introduction of the new tuberculin test. Importantly, however, the occurrence of a sudden fall in the year when gassing had just commenced, but then no significant decline thereafter, does not seem to offer at first sight strong support to the view that the badger control strategy has been effective in reducing the number of herd breakdowns.

86. In an effort to examine the situation more specifically with regard to the areas that were actually subject to badger control, rather than looking at the whole of south west England, a Ministry epidemiologist has analysed the effects on the incidence of breakdowns of badger control by gassing in those areas. The analysis was restricted to the gassing era because insufficient data are available currently to assess the effect of live trapping. A summary of the analysis is reproduced at Appendix 12. In the absence of a formal means of comparison with areas not subject to badger control, the incidence of reactor herds before and after gassing was compared. For each gassed area, the mean incidence of reactor herds from 1960, or when records allowed, to the year gassing commenced was calculated. These rates were then applied to the herds in those areas in the years from the beginnng of gassing up to and including 1983 to estimate the number of reactor herds which would have been expected in the absence of gassing. The net effect of the gassing operation was estimated to be the difference between the expected and the observed numbers of herd breakdowns. The working assumption that the mean incidence of reactor herds would have remained unchanged in the absence of badger control is, of course, open to criticism. For instance some would say that it is likely that the reservoir of infection in badgers is diminishing naturally and thus the incidence in cattle would have declined anyway; or indeed that the control strategy in respect of cattle was sufficient to ensure a steady decline in outbreaks of the disease. Others would

say that the introduction of statutory protection for badgers has possibly led to an increased badger population, an increased reservoir of infection in badgers and, in the absence of badger control, would have caused an increase in the incidence of disease in cattle. There are insufficient data to support or reject either of these hypotheses with any confidence. For practical purposes, therefore, we are prepared to accept the working assumption. As the Ministry epidemiologist recognises, the results of his analyses cannot provide a definitive assessment of the effects of gassing; they represent only an exploration of all information available at the present time, relevant to the assessment. The conclusion of the analyses is that they provide some evidence of a reduction in the rate of infection, to the end of 1983, for cattle herds in gassed areas of about 40% which cannot be explained by other factors.

87. Obviously this estimate may not be entirely accurate. For the reasons given in the two preceding chapters we would expect that the strategy, whether implemented by gassing or live trapping, would fall well short of preventing all herd breakdowns. On the other hand the removal of a substantial number of infected badger social groups should have had an impact on the risk of transmission of disease to cattle. Badger control appears to have had a greater impact on reducing the rate of herd breakdowns in the research removal areas at Thornbury and in south Dorset. Both areas had a history of a high incidence of disease in cattle and in 1975 were amongst the first to be the subject of badger control operations by gassing. After a number of years, the gassing operations were ceased and the natural recolonisation of badgers has been monitored (see Appendix 1—action taken on Lord Zuckerman's recommendation I—where the south Dorset area in referred to as Steeple Leaze). The cattle in both areas have remained clear of infection since the gassing operations ended— in 1978 at south Dorset and in 1981 at Thornbury. However those research areas were subject to more rigorous and sustained control effort when compared to the other areas. They were also a little unusual in that they had some natural boundaries to badger activity.

Economic evaluation of the badger control strategy

88. Ministry economists undertook for us an assessment of the costs and benefits of the badger control strategy covering the period from August 1975 to June 1982, when gassing was the prime method of control in use. The aim was to determine whether, in economic terms, there was a net gain to society from the resources allocated to the control programme. The assessment dealt only in those elements of cost and of benefit that could be specified in quantitative terms and assigned a monetary value. In this sense it did not claim to be an exhaustive evalution, for a number of "intangible" and unmeasurable gains and losses associated with the strategy can be postulated but which could not be handled. However, their estimates do offer for the first time some broad indications of the monetary aspects of the strategy, so that more informed judgements concerning its merit on economic grounds can be attempted. The cost and benefit figures assembled were those that accrue to the economy as a whole, rather than as perceived by the farming industry. This means, for example, that transfer payments between the government and farmers were excluded as they do not represent any consumption of national resources nor contribution to national output. All monetary amounts were collected from, or estimated using, the Ministry's detailed records of control operations over the period, and were then expressed in 1983/84 values (using the retail price index as deflator) so as to allow comparisons on a uniform basis. Because of uncertainty over the measures of certain items, sensitivity analysis was used to establish a range within which the true total figures were expected to lie.

89. The measurable costs of the strategy were taken to be the additional expenditures incurred by the Ministry in conducting the control operations. They do not include the costs of routine tuberculosis testing, laboratory examination, etc., which would have been incurred anyway as part of the wider eradication programme. Totalled over the whole period from 1975/76 to 1983/84 the costs of the strategy were estimated as lying within the range of £10·5 million to £12·8 million, with a point estimate of some £11·3 million (in 1983/84 prices). Almost one half of the costs were accounted for by staff and support expenditures for field operations and supervision, of which two thirds were attributable to the south west region. The other major cost element related to research and development expenditures and amounted to some £3·6 million, with an estimated range of £3·3 million to £4·3 million. It could be argued that many of these research costs might have been incurred as part of the Ministry's general veterinary investigations and so are less directly attributable to the control strategy *per se*. Consequently, the net economic merits of the strategy are assessed to give two alternative answers depending on whether or not they are included.

90. The measureable benefits of the control strategy appear through the number of herd breakdowns that are prevented. Their total value was calculated as the product of (a) the estimated reduction in the number of (confirmed and unconfirmed) herd breakdowns attributable to gassing operations and (b) the appropriate estimated average costs of a herd breakdown. Benefits therefore appear as losses/costs avoided. Estimates of reduction in herd breakdowns over the period were derived from the epidemiologist's analysis referred to earlier in this chapter, and the economic assessment is therefore also subject to the uncertainties that attach to that analysis. Over the period 1975–1983 a total of 244 confirmed and 136 unconfirmed breakdowns are estimated as having been avoided as a result of gassing, the annual reduction having stabilised at around 60–65 cases annually over the last five years (being approximately 40 confirmed and 25 unconfirmed cases).

91. In placing an average value on each of those incidents "saved", estimates were made of costs incurred both by the Ministry and by the farmer in the case of a breakdown. Ministry costs included net compensation payments for slaughtered cattle, veterinary investigation and follow-up tuberculosis testing, with *post mortem* and laboratory examination of the cattle carcases. In 1983/84 prices these together amounted to some £3850 for a confirmed breakdown and £1245 for an unconfirmed one. The farmer's costs include the net loss on slaughtered cattle (since compensation on reactors covers only 75% of the market value), farm labour for the

additional tuberculosis testing associated with a breakdown, reduced milk yield as a result of testing, plus losses of margin on reduced cattle throughput and calf sales as a result of the movement restrictions imposed. Using 1983/84 market prices, these in total were estimated at £2505 and £445 for confirmed and unconfirmed breakdowns respectively. While these figures measure the financial cost to the farmer, the loss to the economy is somewhat less since products that are in surplus supply and supported at above world prices have a real value to society lower than that reflected by their domestic market price. Taking this adjustment into account, the overall cost of a breakdown—and hence the benefit gained if it is avoided—is estimated on average to be about £5700 for a confirmed incident and a little over £1500 for an unconfirmed one. On this basis the accumulated benefit from the control strategy over the period 1975–1983 was estimated to lie within the range of £1·4 million to £1·8 million, with a central estimate of £1·6 million.

92. The sequence of measured costs incurred from 1975 until gassing operations ceased in June 1982, and the consequent series of measured benefits that accrued each year up to the end of 1983, were each totalled and then compared to ascertain a calculated net economic value (gain or loss) derived from the strategy. In order to account for the fact that a given benefit or cost that arises now is, in fact, worth less than the same sum arising some years earlier, all monetary amounts were expressed as a "present value" at a base period of 1983/84. This involves a standard accounting procedure whereby sums of money are compounded annually at a specified rate of interest (in this case the so-called "test discount rate" of 5%) from the year they arise up to the base period.

93. The present value of the total strategy costs amounted to £9·7 million, or £6·5 million if research costs are excluded. Against this, the present value of the strategy benefits amounted to about £1·9 million. The difference between the two estimates yields a *net* present value of − (minus) £7·8 million, and sensitivity analysis indicates it is unlikely to be outside a range of −£7·25 million to −£9 million. If research costs are excluded the net present value rises to −£4·7 million (ranging from −£4·5 million to −£5 million). The gassing phase of the strategy ceased in June 1982 but the benefits arising from it will have continued, since the removal of infected badgers would be expected to prevent a succession of breakdowns that might otherwise have occurred later. The magnitude of any such benefits would depend on the speed with which badgers repopulate gassed areas, the extent to which those badgers are infected and the rate at which the disease might be transmitted to cattle. The measured net present value of the strategy is enhanced by any such benefits which may arise. However, even if one accepted the extreme assumption that a continued reduction in breakdowns of some 60–65 annually were to be experienced indefinitely, the present value of the benefits arising in the future would never be sufficient to exceed the full costs already incurred. Thus, the strategy could never "break-even" in the financial sense. If research and development costs are excluded, the gassing programme would need to lead to 65 fewer breakdowns every year for 50 years before it will have covered its costs.

94. This economic assessment was based only on the gassing phase of the control strategy because, as yet, there is insufficient information to allow any equivalent conclusions to be drawn concerning the effect on herd breakdowns of badger control by trapping. Even if trapping does prove more successful in this respect, thus yielding higher measured benefits, it inevitably also involves higher measured costs because of the greater labour requirements. However, using the data generated in this assessment exercise, some reasonable estimates can be made as to the necessary level of achievement of the trapping strategy if it is to be justified in economic terms. Let us assume: (a) the costs of badger control operations continue at their 1983/84 level (i.e. about £2 million per year in total, or £1·5 million net of research and development costs); (b) the mean incidence of herd breakdowns would remain at a constant level in the absence of badger control; (c) trapping operations reduce the number of herd breakdowns below this level by 60–65 annually, as estimated for the gassing strategy; and (d) the cost of a breakdown remains unchanged at the level already estimated. Under these circumstances, the badger control strategy would need to prevent over 200 confirmed breakdowns and 100 unconfirmed breakdowns each year in order for its measured benefits to cover its measured costs. The number of confirmed breakdowns in the control areas has been at a level of about 80 a year on average over the last five years. Adding in the estimated 40 confirmed cases annually that the gassing strategy is estimated to have prevented suggests that the "uncontrolled" level of incidence might be in the order of some 120 breakdowns per year. On this basis it appears technically impossible for the control strategy ever to achieve a sufficient reduction in breakdowns to generate a level of benefit even approaching the operational costs. Nor does the available evidence suggest that continued implementation of the control strategy would reduce the annual incidence level below the threshold of one infected herd in 10,000 which would permit the costly regime of tuberculosis testing to be dispensed with, and so give rise to an added annual saving to the Ministry of some £5·5 million, plus other savings to farmers.

95. The main conclusion to be drawn from this analysis is that, *in terms of those elements that can be measured,* badger control by gassing resulted in a net economic loss to the nation. Two points must be borne in mind when considering this statement. First, a zone of imprecision inevitably surrounds the estimated value of that loss. The costs attributed to the strategy may have been overestimated since, for example, the Ministry's expenditure (especially as incurred in central and regional veterinary administration) may not be reduced by the assessed amount if the strategy were to be abolished. On the other hand, the benefits of the strategy may be overestimated, since there is some doubt on statistical grounds whether the control strategy did achieve reductions in herd breakdowns of the magnitude used in this analysis. Added to this, there are a number of unquantified benefits to the strategy, being its part in enhancing the achievement of the wider benefits of tuberculosis eradication. These include, for example, improved human health, higher output and greater efficiency in milk production, greater consumer confidence in meat and milk, the fostering of cattle exports, plus the reduction in damage to crops, hedges and grassland by badger activity. Against this, there are unquantifiable costs to the control strategy—not the least of which is the loss to the community from a reduced

badger population, and the concern felt by many in society from knowing of the existence and nature of the Ministry's control operations.

96. Similar issues of intangible, unquantifiable and accessory effects surround all economic evaluations of public policy decisions, and prevent such assessments ever claiming to be complete or definitive. However, as in all such exercises, the aim is merely to set formally against one another those costs and benefits that can reasonably be identified, quantified and measured in monetary terms; this reduces the zone of the problem within which purely judgemental assessments must be made, and also highlights clearly the issues about which those judgements must be made. In the context of the badger control strategy, the key question that must be asked is: Are those additional unquantified benefits associated with better human health, improved efficiency in milk production, reduced disruption to livestock farming operations, etc., and attributable to the badger control strategy, likely to have been worth to society an expenditure of over £7 million in public resources over seven years that might have been allocated elsewhere in the economy? We believe that most people would judge the answer to this question to be "No".

PART III – CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 8

GENERAL CONCLUSIONS AND ALTERNATIVE STRATEGIES

Eradication of the disease in cattle

97. We have not considered the continuing justification for the overall policy on the eradication of bovine tuberculosis in cattle, for this would go beyond the scope of our remit. Critics of badger control question the need for such an eradication policy, given what they regard as the now negligible risk to public health from infected cattle. However it remains the case that untreated milk is still drunk in appreciable quantities, especially in rural areas, and there is also a slight risk of infection for humans in close contact with infected cattle. It is difficult to quantify these risks, and information on the incidence of bovine tuberculosis in humans is unobtainable because routine typing is not carried out to differentiate between bovine and other forms in human cases. There are also economic benefits in terms of production and trade which would have to be measured against the cost of the policy. Furthermore while an EC Directive requires an expensive programme of cattle testing until a specified low level of herd incidence is achieved, there remains a stimulus to "eradicate" the disease at least to that level. Our assumption must be that the overall tuberculosis eradication policy will continue with the objective of keeping the lowest possible levels of bovine tuberculosis in cattle.

Badgers

98. Though badgers may constitute the main source of re-infection of cattle with bovine tuberculosis, we cannot overemphasise that there are still many gaps in our knowledge of the epidemiology of the disease in badgers, despite the effort which the Ministry has put into research on this problem. As we have commented earlier we know little of the distribution and prevalence of the disease in the badger population, and of the size and distribution of the badger population in Britain. The Mammal Society of the British Isles is making efforts to update and improve the estimates of the distribution and density of badger setts in Great Britain which they provided for Lord Zuckerman's Report. The University of Exeter is studying badger populations in selected areas of south west England to seek any correlations with habitat types, in the hope that predictions of badger populations might be made more widely using land classification maps. The Nature Conservancy Council has made a grant to the University of Bristol for a survey of badger numbers in Britain using informed volunteers to carry out much of the work. These initiatives are welcomed because any improvement in the population data will be of value. At the time of writing no definitive results are available from these studies. Nonetheless we have seen no evidence to suggest that the current strategy is a threat to the badger population as a whole, although obviously badger removal operations will have a temporary effect on local badger populations. There are large tracts of the country where cattle and badgers co-exist with no signs of tuberculosis in either species. Studies in the Ministry's Gloucestershire study area have also shown that the disease does not pose a serious threat to the badgers even where it is known to exist in the local badger population. Bovine tuberculosis is a relatively insignificant factor in the mortality of badgers even in these areas, and individuals can live with the disease for some years.

99. The evidence available suggests to us that infection in badgers is probably widely but sparsely and unevenly distributed throughout the badger population. New geographical sites of infection have been identified in recent years, either as a result of the investigation of herd breakdowns or the examination of badger carcases reported by members of the public. We do not interpret this as evidence that the disease in badgers is spreading but rather that it exists, perhaps at low levels of incidence, in many parts of the country.

100. The suggestion has been put to us that the translocation of badgers, either by misguided animal activists or in connection with illegal activities such as badger baiting, has played a role in the spread of the disease in badgers. We have sought firm evidence of this but, naturally, such evidence is hard to come by. Clearly it is possible that the disease may have been transmitted in such circumstances, but this is unlikely to have been the cause of all the newly identified sites of infection in the country. However, translocation of infected badgers could make the disease situation worse.

Current strategy on bovine tuberculosis and badgers

101. We have indicated in Part II of the Report the reservations we have about the Ministry's current strategy for badger control. Our view of the distribution of the disease in badgers leads us to question the validity of the "clean-ring" approach (see Chapter 5). We have doubts about some of the operational aspects – which appear somewhat cumbersome – and the current strategy may be failing in part because of the shortcomings of the sampling procedures that have been adopted (see Chapter 6). We cannot be confident about any interpretation made of the data on the incidence of disease in cattle in attempting to reach a judgement on the impact of the strategy (see Chapter 7). We also have doubts about the success of the strategy when measured in economic terms (see Chapter 7). Overall we conclude that there is insufficient evidence to justify the continuation of the current strategy.

Cessation of badger control

102. We have given full consideration to the option of ceasing any form of badger control. Given the success of the current strategy is unconvincing, we were drawn logically to recommend that no action should be taken against badgers and that greater compensation for farmers should be paid in the event of a herd breakdown. It

may be that when more is known about the epidemiology of bovine tuberculosis in badgers, and if a reliable diagnostic test became available, this might become the best policy to follow. In the long term a policy based on having no form of badger control would have to include the setting of thresholds for the incidence of disease in cattle, linked either to national economic considerations or to the statutory levels in the EC Directive which determine the frequency of tuberculin testing. If these thresholds were exceeded for a stated period, consideration would then have to be given to the re-introduction of a control programme if there was sufficient evidence to implicate the badger in this rise in breakdowns. Before adopting a "no action" policy one would need to be reasonably convinced that these thresholds would not, in fact, come into play. At the moment there are so many gaps in our knowledge that we could not be confident that, if badger control ceased completely, there would not be an unacceptable increase in the number of herd breakdowns. It must be recognised, too, that any rise in the incidence of tuberculosis in cattle herds in south west England increases the risk of breakdowns occurring in the rest of the country through the movement of animals in trade.

103. The appropriate level of compensation for a farmer remains problematieal. Some see a case for compensation to cover the full market value of the animals slaughtered and the consequential losses suffered in a herd breakdown. Against this it is argued that if all losses are fully compensated, the farmer loses any incentive to take reasonable action to reduce the risks of a breakdown occurring. However it is also argued that no financial compensation as conventionally calculated could cover the loss of a pedigree line built up over many years. In the present state of knowledge, even if they were offered greater compensation, some farmers might be tempted to take indiscriminate and illegal action against badgers to avoid the risk of disease transmission in the absence of a Ministry control strategy.

104. It has been suggested that a policy of no badger control could be associated with a programme of more frequent testing of cattle in the "problem" areas, on the basis that it would reduce within–herd and, perhaps, herd-to-herd transmission of the disease. The Ministry's economists have estimated that the costs of moving to 6-monthly testing for the 6,000 herds in south west England currently on annual testing would be £1½ million per annum with likely benefits of only up to £½ million. We cannot recommend this as a viable option.

105. We conclude that, for the time being, we cannot recommend the cessation of badger control.

Future policy and strategy on bovine tuberculosis and badgers

106. Given our view of the distribution of tuberculosis in badgers and the methods available for dealing with it, we conclude that the complete and permanent eradication of the disease in badgers, and hence in cattle, is unattainable. In our view the objective of the policy should be to limit the transmission of disease from badgers to cattle by dealing with identifiable and avoidable risks, quickly and effectively at a reasonable cost. This comes close to the Ministry's declared objective (set out at paragraph 18) but we believe it could be achieved just as satisfactorily with a more limited strategy of badger control at significantly lower resource costs, and more acceptably to conservation interests. Furthermore, we emphasise the importance of acting speedily in the event of a breakdown being clearly linked with badgers if the logic of the removal objective is to be sustained.

107. In the following paragraphs we discuss the range of options for strategies to implement such a policy. We have recommended in the first place an interim strategy with limited badger control which we believe will be workable. If this is undertaken, there will be additional data to improve the understanding of the problem. It might be that when sufficient data have been compiled, including the results of the research projects which we recommend in Chapter 9, some changes in the level of badger control, or even none at all, will prove to be the way forward. Although remote, there is also the possibility that a vaccine might be developed for use in badgers which, if used successfully, would reduce the overall disease levels in the species. In the meantime we emphasise the importance of developing a diagnostic test for bovine tuberculosis in living badgers both as a research tool and as a means of accurately discriminating between infected and healthy badgers if badger control is to continue.

Interim strategy for badger control

108. In the light of the evidence currently available we conclude that, for the time being, some form of badger control is unavoidable. However, we feel it is justifiable only in situations where it can be demonstrated that badgers are the most likely source of the disease for cattle – i.e. after a herd breakdown for which no other source of infection can be identified. We do not consider that action against badgers is justified where an infected badger is found, e.g. as a result of a road traffic accident, but where there is no concurrent disease in cattle in the immediate vicinity for the following reasons. First there is always the problem of identifying exactly where such a badger came from. Second, if our view of the distribution of the disease in badgers is correct it is likely that, in many areas of the country, infected badgers can exist with an extremely low probability of transmitting the disease to cattle. Other, as yet unexplained, factors must also play a part in the mechanism of disease transmission from badgers to cattle. Such factors might be a particularly large number of infected badgers locally, large numbers of cattle on pastures used by badgers, and even badger access to cattle food.

109. Also we do not believe that action against badgers is always justified in parts of the country where unexplained herd breakdowns are isolated and sporadic. If, in such areas, a second unexplained herd breakdown occurs in close proximity to the first then it may be thought that favourable circumstances for transmission of the disease from badgers to cattle may persist locally and the need for some action against badgers (possibly involving initial sampling) should be the subject of discussion with the Consultative Panel on Badgers and Tuberculosis. On the other hand, in areas where there has been a recent history of herd

breakdowns for which infected badgers were identified as the likely source of infection, we conclude that it would be justifiable to take action against badgers following an otherwise unexplained herd breakdown.

110. In recommending an interim strategy for badger control in such circumstances, we emphasise that we have had to do this in the absence of much relevant information on the problem, and therefore have had to be largely pragmatic in our approach. We have already expressed our doubts about the efficacy of current procedures for the delineation of badger social groups and the sampling of two badgers per social group. The doubts about the sampling regime in particular lead us to believe that a majority of those herd breakdowns which are classified finally as "source of infection unknown" (see Appendix 5) could well have been caused by infected badgers which were not detected by the sampling procedure. Therefore, in areas where there has been a recent history of herd breakdowns attributed to infected badgers, it is reasonable to presume that if other sources of infection have been investigated fully and dismissed, infected badgers are the most likely source of new herd breakdowns and should be removed. We recommend that, in such circumstances, all the badgers using that part of the breakdown farm where it was believed that the disease was transmitted to cattle, or the whole farm if it is not possible to be more precise, are captured, killed and examined *post mortem,* without prior sampling or delineation of social groups. We recognise that in some circumstances this will mean capturing badgers resident in setts on a neighbouring farm but using runs on the breakdown farm. This may be more time-consuming than trapping all badgers at their sett entrances. However we believe that this would be more than offset by savings of time, effort and resources currently expended in ineffectual sampling and unreliable social group delineation. It might be that a greater proportion of badgers using the area would be missed by the initial removal than under the present scheme. Hence, a programme of return visits, for say three months, would be necessary to capture as many of the badgers which had been missed as possible (whether or not infection was found in the badgers removed initially) since it might have been the infected individuals that were missed. Whatever the infection status of the badgers removed there would be no question of extending the badger removal operation beyond the breakdown farm in an attempt to find a "clean ring". Obviously if such a strategy found no infection in the badgers removed in a significant number of cases, the strategy would have to be reconsidered.

111. This interim strategy would overcome many of the undesirable delays inherent in the current programme. There would be a greater certainty that any infected badgers captured were the source of the herd breakdown, and that source of infection would be removed quickly. Given our view of the distribution of the disease in badgers, and the generally slow rate of recolonisation of cleared areas, we believe farmers will be no less protected from the risk of further disease transmission than they were with the "clean ring" approach. We make no recommendations, therefore, for change in the current compensation arrangements for farmers. The more limited scale of the operations should result in many fewer badgers being killed, and should result in the release of some resources for use on other aspects of the programme. In the context of these more limited badger operations, we see no scientific justification for continuing the practice of releasing lactating female badgers. This practice runs counter to the logic of any attempt to remove a reservoir of infection and thus militates against the speedy and successful conclusion of control operations. Our recommended interim strategy is premised on a quick response to situations where it is shown that badgers were the most likely source of the disease for cattle, and therefore it implies a need to remove all individuals using the breakdown farm, or that part of the breakdown farm where it was believed the disease was transmitted to cattle. As we have pointed out in paragraph 77, infected lactating females may well transmit the disease to their cubs through their very close relationship with them, and there is the serious practical difficulty that operators are frequently unable to recognise whether females are lactating or not. All of this leads us logically to suggest that, in the removal operations which we are recommending, lactating female badgers should be treated no differently from other badgers. Since operators find such difficulty in recognising captured lactating females, the only way to protect them would be to have a close season on all badger operations for several months. Not only would this introduce a logical inconsistency into our proposed strategy, it would have severe operational drawbacks. There would be difficulties for the Ministry in making any control procedures effective if they employed a workforce to undertake badger operations for part of the year only. During the "close season" the risk of further transmission of the disease, between badgers and from badgers to cattle, would remain. Further, the lactating female badgers and their cubs would stand to be captured and killed at the end of a close season anyway.

112. The delineation of the areas in which a strategy of limited badger control should operate will require some objective judgements to be made. By selecting areas in which there is a recent history of herd breakdowns attributed to badgers, account would be taken of the factors which had caused infection in badgers to spill over into cattle, despite those factors not being fully understood. Although it is envisaged that badger control would be limited to the breakdown farm, appropriate powers of entry might still be needed to enable operators to go onto neighbouring land to find setts and thereby aid their identification of badger runs leading onto the breakdown farm. A revision of the Badgers (Control Areas) Order 1977 appears to be a suitable vehicle for a public expression of what those areas should be. We recommend that the Ministry undertake the necessary consultations with a view to placing a revised Order before Parliament with statutory Control Areas based on the definition given above.

113. We recognise fully that our recommended interim strategy implies a much more limited control of badgers following their implication in a herd breakdown. We have already discussed in some detail the unavoidable uncertainty surrounding any interpretation of the trends in the incidence of herd breakdowns, and in particular whether there does exist an underlying tendency in south west England for incidence to rise but which has been suppressed by the current control strategy. In the light of this uncertainty we have to recognise

the possibility that those who assert that the number of breakdowns would rise dramatically if badger control were restricted could be correct. We consider it to be prudent, therefore, to specify certain upper limits in the level of future breakdowns which, if exceeded, would cause us to reconsider the effectiveness of our proposed strategy of more limited control. The incidence of breakdowns fluctuates greatly from one year to another, and so the mere occurrence of an increase in the next one or two years cannot in itself be regarded as sufficient evidence of a rising trend. Applying standard statistical criteria we estimate that only if the mean annual incidence of breakdowns over the next three years exceeds 1·45% of herds, or 1·25% over the next five years, could we conclude that there was evidence of a significant increase in breakdowns following the adoption of our proposed strategy.

Method of badger control

114. We have considered all the evidence submitted on different methods of euthanasia for this species. We have concluded that there is no alternative available now or in prospect for a more efficient and humane method of killing badgers than that currently employed. One great advantage of live trapping is that the subsequent availability of badger carcases provides much needed scientific information. We are pleased to note that the Ministry has established a national computerised system designed to collate data on the bovine tuberculosis and badgers problem, and would emphasise that adequate resources must be made available to allow collection and analysis of the data arising from the badger control strategy.

Who should undertake badger control?

115. Amendments to the Badgers Act 1973, which are contained in the Wildlife and Countryside Act 1981, were brought into effect in February 1982. From that date it became illegal for owners or occupiers to kill or take badgers on their land unless they had been granted a licence to do so; exceptions to this relate to dealing with injured badgers. Anyone wishing to kill or take a badger for the purpose of preventing the spread of disease must apply to the Agriculture Departments for a licence to do so. The Agriculture Departments have not issued such licences so far and we believe that this should remain their policy. We consider that the only circumstances in which action against badgers is justified are those in which a limited badger removal operation would be undertaken on the lines we have proposed. We recommend that such operations should continue to be undertaken by Ministry staff who have the necessary skills, experience, equipment and access to the existing database on the problem which they can augment with data from the operations. Most of all they are likely to conduct the job in a humane manner under well-defined conditions susceptible to scrutiny and supervision.

More extensive badger control

116. It has been put to us that the aim of preventing the spread of tuberculosis might be achieved better if badger control was applied more extensively in "problem" areas. One possibility is that the population density might be reduced over a wide area to a level where the disease might die out. Research relevant to such a proposal has been undertaken at Imperial College, London, where mathematical models were used to analyse the population biology of the badger and the epidemiology of bovine tuberculosis within badger populations, albeit constrained by the very limited data available. From this it appears that infection is likely to persist even where badger numbers are very low. Only complete elimination of the badger, therefore, would achieve the eradication of the disease in an area.

117. A related possibility for a more extensive badger control strategy would be the reduction of the badger numbers in "problem" areas in order to reduce the risk of transmission of the disease to cattle, without actually seeking to eradicate the disease. From the research undertaken at Imperial College, it appears that relatively small reductions in the density of badger populations would have little effect, as rapid population growth to pre-control levels would take place. Therefore any effort to this end would need to be repeated and sustained indefinitely to be effective. Only when badger numbers are reduced substantially, as in current Ministry operations, is their recovery rate poor, taking several years to reach pre-control levels. Such a strategy assumes a degree of density dependence for the disease in badgers. This may be the case but there is no clear evidence for such a proposition because, within setts, badgers live in relatively close proximity to each other even in areas of low overall badger population density. On the basis of our current knowledge, we believe that a strategy of sustained suppression of badger populations is unlikely to be practical, would be very costly and would be unacceptable on ethical grounds. These judgements apply even more to any strategy for the wholesale elimination of badgers from "problem" areas.

Strategy based on a diagnostic test in living badgers

118. We believe that the development of a diagnostic test in living badgers is highly desirable, not only as an aid to research, but also as the basis for a more discriminatory and acceptable strategy for badger control. The indications are that, with sufficient resources, within five years or so it should be possible to develop a field test for tuberculosis in badgers capable of providing a diagnosis in ten to fifteen minutes. Control operations following a herd breakdown would then involve trapping, sedating, marking and blood sampling of badgers. Infected badgers would be killed and those giving negative test results would be released, probably to be caught and tested three months later to check that infection in the local badger population had been removed. In comparison to the current strategy, and in common with our recommended interim strategy, such operations would maximise the chances of finding any infection in the badgers and enable that source of infection to be removed quickly. Although more field resources might be required for these trap/release operations than for the interim strategy, after a period of checking the efficacy of the diagnostic test, there would be savings to be made in laboratory resources because much of the *post mortem* and laboratory examination of badgers could be dispensed with. Even more importantly from an ethical viewpoint only infected badgers would be killed.

Treatment of tuberculosis is usually ineffective and would be impractical in a field situation. The removal of fewer badgers should also avoid some of the disruption to social groups caused by the current or our recommended interim strategy, and blamed by some as a cause of disease spread. The areas to be subjected to such operations would depend on (a) the cost of the operations and (b) on the outcome of continuing research into such matters as the extent of disease transmission between badger social groups. Initially, such operations would probably be as limited in extent as those in our recommended interim strategy.

119. All these changes depend on the development of a reliable and effective diagnostic test. In this respect promising research is being undertaken at the Ministry's Central Veterinary Laboratory in collaboration with medical centres in the London area. The development of a suitable field test falls into three stages. First, the identification of specific, unique antigens on the cell surface of *M.bovis*; work on this is already well-advanced and we understand that new techniques are becoming available which will make such an analysis faster and more comprehensive. Second, monoclonal antibodies need to be produced for those antigens identified in the first stage, which are found on *M.bovis* and not on other mycobacteria. Third, the laboratory test needs to be modified into a kit form suitable for use in the field. Although the Ministry should co-ordinate these various stages, we believe that other laboratories may be better equipped to carry out the work quickly and that different laboratories may be better suited to each stage of this work.

120. The development of such a test is so important that we recommend resources should be transferred from other areas of the programme to speed up its progress. Research on monoclonal antibodies specific to mycobacteria would lead to a more humane and efficient strategy for the control of the disease in badgers and could also lead to a more specific test for *M.bovis* to back up the tuberculin test in cattle.

Vaccination of badgers

121. The idea of a vaccination strategy for badgers has received significant support from many of those who have submitted evidence to us and is the subject of a charitable appeal by one conservation group. Research related to the possible development of a vaccine has been undertaken at the Middlesex Hospital Medical School and at the Ministry's Central Veterinary Laboratory. Evidence of cell mediated immunity has been detected in a group of badgers inoculated intradermally with *M.bovis*. A further group of badgers, some of which had previously been inoculated subcutaneously with BCG vaccine, were challenged intradermally with live *M.bovis*. In the vaccinates the inoculation sites healed more quickly and in some of the badgers the tuberculous lesions found *post mortem* were less severe that those in unvaccinated animals. This very limited work suggests that, contrary to earlier presumptions, there is some immune response when badgers inoculated with BCG are challenged with *M.bovis*. However, the research is at a very early stage.

122. The prospects for the development of a vaccine for badgers have to be viewed against the hundred years of work (and its associated controversy) aimed at producing a safe and effective tuberculosis vaccine for man and cattle. This work continues and has relevance to the situation in badgers. Killed vaccines are safer to use but, although many have been tried, live BCG vaccine remains the only practical means of providing some immunity in man. In cattle, experiments have been conducted with live BCG and with *Mycobacterium microti*, and a degree of protection can be achieved under carefully controlled, experimental conditions. Trials of BCG vaccine in cattle have shown at best a small increase in protection which was of short duration and which could not be increased by revaccination. The use of a living bacterium is a limiting constraint in developing a vaccine for any wildlife species because of the risk of the organism becoming pathogenic in other wildlife, domestic animals and man, all of which might be more susceptible to clinical disease than the target species. Although BCG vaccine contains an attenuated bacterium which appears to be remarkably stable, reversion to a virulent state via passage through other wildlife species is a remote possibility. Also, the excretion of BCG by badgers might lead to its transmission to cattle and so interfere with the efficacy of the current tuberculin test because of the immune response thereby induced, and even to the excretion of BCG bacilli in the milk. Thus the research so far on BCG vaccine in badgers has been conducted with a view to finding out more about the immune response of the badger, rather than with a view to its practical use.

123. Even if these problems could be overcome, the practical problems of the delivery of a vaccine to badgers and the assessment of its effectiveness would remain. Rather than the prevention of infection, the best that can be achieved currently with mycobacterial vaccines is the limitation of the development and multiplication of the lesions. Vaccination might have a direct effect by limiting the development of tuberculosis in vaccinated animals and, because of a reduction thereby in the number of animals becoming infectious, might reduce the chances of infection in non-vaccinated animals. However, unless the vaccine produced permanent immunity, there would be a continuing need to re-vaccinate badger populations. And anyway, an annual programme of vaccination would be necessary to take account of each year's "crop" of new cubs. Not only would that represent an enormous cost, but it highlights also a further area of particular difficulty. It seems likely that a significant means of transmission of the disease in badgers results from the close relationship between a mother and her cubs. Consequently, a number of animals might acquire infection before becoming available for vaccination (whether by trapping and inoculation or by oral vaccination via bait consumption).

124. In the light of all these considerations we conclude that there is little likelihood of a vaccine being developed successfully in the near future, consequently we make no recommendation now for a strategy based on its availability. Background research on the immunological response of the badger and on the structure of *M.bovis* as part of the development programme for a diagnostic test in living badgers may provide more information which could lead to new ideas for vaccine development. If a diagnostic test in living badgers and the tuberculin test in cattle were to continue to be of value, a vaccine for badgers would only be practical if it was

possible to differentiate the immune response to it from that to natural infection with *M.bovis*. We would not want to discourage any new and promising lines of research aimed at a possible vaccine for the future, but this must remain only a long term hope with little prospect of progress during the next five years.

Action to keep badgers and cattle apart

125. Some of those submitting evidence to us suggested that poor management practices in some areas of the country played a part in the transmission of disease. We found no evidence to support this contention. Nevertheless, there is a range of options open to farmers that could reduce the risk of transmission of bovine tuberculosis from badgers to cattle. Research has been conducted recently at the University of Reading (under contract to the Ministry) to examine those aspects of cattle and badger behaviour that might be relevant to the risk of disease transmission, and to look at management practices that could affect the level of contact between cattle and badgers and their urine and faeces. The results suggest that there are a number of possible actions farmers could take to reduce the risk of disease transmission. Some would almost certainly be too costly or impractical for farmers to implement. Other tentative suggestions would require much further research on the persistence of *M.bovis* in the environment, and on cattle management practices used by farmers. For both subjects there will be so many varying and uncontrollable factors that we believe further research is unlikely to be rewarding.

126. However, there are two suggestions which we feel farmers could take up at a reasonable cost, and we recommend that the Ministry encourages them to do so. The first is to prevent cattle having access to badger setts and, where practical, latrines, by fencing them off. This would not stop infectious badgers contaminating pastures, but it would prevent the risk of disease transmission at the setts and latrines themselves. Observations have been made of cattle rubbing their heads on badger sett entrances and this behaviour obviously provides an opportunity for disease transmission. The second suggestion is to prevent, as far as possible, badgers and cattle eating from the same food source. Some cattle foods (e.g. cereals and dairy nuts) appear to be particularly attractive to badgers and should therefore be fed in the field only in "badger-proof" troughs. Research suggests that troughs for food and water should be at least 80 cms high and with smooth, solid walls. Because of the observations made of infected badgers occupying farm buildings, efforts could also be made to deny badgers access to food stored in buildings.

127. Suggestions for more far-reaching methods of keeping badgers and cattle apart have been put to us. One such suggestion is that on farms considered to be at risk, the cattle grazing areas should be fenced off to prevent badger access. This option was costed by Ministry economists who estimated that, if the farms in south west England undergoing an annual tuberculin test were considered to be those "at risk", the installation of fencing could cost anything from £120 million to £240 million. With potential benefits estimates at about £1 million per annum, this is clearly not a viable option. A more extreme suggestion is that cattle should not be kept in the affected areas and that farmers should change to some alternative form of livestock or arable farming. Using the definition of "at risk" given above, this would imply something of the order of half a million hectares of land being taken out of cattle production. The resulting adjustment and compensation costs to agriculture are likely to be very high, and would probably far outweigh the net cost of the current badger control strategy. A detailed cost benefit study of this option has not been attempted. Individual farmers are, of course, free to decide for themselves whether to carry the risk of their cattle herds becoming infected with tuberculosis, or to choose some other production alternative if this seems economically worthwhile.

CHAPTER 9

RESEARCH NEEDS

128. Despite the research effort made over the last ten years or so, largely by the Ministry, the current state of knowledge of the population biology of badgers and the transmission dynamics of bovine tuberculosis is still limited. We emphasise again that our review of the problem of bovine tuberculosis and badgers, and our assessment of the success of the current strategy, have been constrained by the availability of information. Our recommendations for alternative strategies have to be viewed in that light also, and can only be regarded as subject to adjustment as the understanding of the problem is improved by more and better information. In considering the needs for further research we have sought to identify important relevant gaps in knowledge, which, if filled, are likely to lead to future refinement of the policy or strategy.

Diagnostic test for bovine tuberculosis in living badgers, and vaccination of badgers

129. As indicated in the previous chapter (see paragraphs 118-120) we emphasise the need for the development of a diagnostic test in living badgers. Such a diagnostic test could not only be used as an operational tool, but would also assist greatly in other research areas on which we comment in the remainder of this chapter. The research required to develop this test will lead to a clearer understanding of the immunological response of badgers to infection by *M.bovis,* and this will itself be an essential early stage in any programme to devise a vaccine. While we see the diagnostic test being achievable in the short term (say 3 to 5 years), we regard the research on the vaccine to be longer term and the development of procedures to apply it in the field even longer. In very broad terms the likely cost of research on the diagnostic test would be approximately £150,000 per year.

Field studies of badger population biology and transmission of tuberculosis

130. Much valuable information has been gathered on these aspects from the Ministry's Gloucestershire study area and we have drawn on this information throughout our report. The study area was chosen so as to be in one of the main disease problem areas, and is located in a deep valley in the Cotswold escarpment, covering an area of some 8 square kilometres. When the project started in 1975, research centred on the biology and ecology of the badger, but from 1981 was extended to cover epidemiological aspects as well. The research has indicated; *inter alia*, that infected badgers can survive for several years and that badgers have a low intrinsic population growth rate. These facts, and others, indicate slowly changing population patterns and processes, and point to the need for long term research if we are to gain a detailed understanding of disease transmission between badgers and the response of badger populations to localised reduction and eradication. The research has also shown that cattle and infected badgers can co-exist without the disease being transmitted to cattle, as the last herd breakdown in the study area occurred in 1981.

131. Continued research at the Gloucestershire study area will provide more information (by clinical sampling, prior to the development of a diagnostic test) about the progression of disease in individual badgers and the transmission of the disease within and between badger social groups. More observations will be made on the interaction between badger social groups, the movements of badgers (particularly infected individuals), badgers' use of habitat and coincidence with cattle, long term changes in badgers' population dynamics and, as parts of the study area have been subject to badger removal action, the speed of recolonisation of cleared areas. The study area will also provide an important field laboratory for the development and testing of the diagnostic test, and the availability of the test will greatly enhance the research.

132. The scientific rewards from the current project will increase as time goes on and we recommend that it should continue for at least another five years. Given the presence of infected badgers in the study area there is some risk of transmission of the disease to the cattle there. The support given to the project by the local herd owners is to be commended, and it is important that adequate compensation terms are available to these farmers so that, in the event of a herd breakdown in the area, the continuance of the programme can be ensured. Clearly under such circumstances particularly valuable information would become available about transmission from badgers to cattle. For maximum benefit from the programme a fully integrated multi-disciplinary approach, involving several sections of the Ministry and scientists from other oganisations, is required. Having visited the study area we recommend that the facilities there be made adequate for such work to be developed and conducted effectively.

Areas of no badger control

133. In measuring the effect of any badger control strategy on the incidence of herd breakdowns, there would be considerable value in having scientifically comparable information from areas where badgers are known to be infected but which are not subject to control operations. The Gloucestershire study area has, in part, provided one such area and the research area in East Sussex was another for the three years of the wildlife sampling project there prior to the commencement of the badger removal operation. A suggestion for more "no badger interference zones" was put to us early in our review by the Wildlife Link Badger Working Group and it received support from other conservation interests. We benefitted greatly from that Group's initiative in drawing together the views of many conservation interests in their report on "Badgers, Cattle and Bovine Tuberculosis". However we have great difficulty in accepting their concept of "no badger interference zones", either in principle or on the scale proposed. For such areas to be of real benefit in terms of improving our

understanding, they would have to be studied on much the same lines as at the Gloucestershire study area, for a long period of time. Without data on the incidence of disease in badgers in such areas, comparison with areas subject to control would be largely meaningless. The cost of maintaining study areas like that in Gloucestershire (in 1983–84 the cost of research there was some £250,000) makes it impractical on a wholesale basis. If "no badger interference zones" were not closely monitored, it would be tantamount to adopting a partial strategy of ceasing badger control altogether; we have already indicated why we consider such a step to be unjustified at present.

134. We recognise that the habitat of the Gloucestershire study area may be exceptionally favourable for badgers and it has the highest density recorded for badgers in Europe—approximately 20 adults per square kilometre. Thus it may not be appropriate to base conclusions for the whole country on the research undertaken there. We considered recommending that the Ministry should set up a replicate of the Gloucestershire study area in another part of the country with a low badger population density and known infection in the badgers. However, such a project would be costly and would have to continue for say ten years to produce meaningful results. All the points we have made on the Gloucestershire study area with regard to facilities, a multi-disciplinary approach, co-operation of local farmers and special compensation arrangements would be applicable to any additional study area. Because of the costs involved, we make no recommendations for other study areas of no badger control. We do this reluctantly as we recognise that without such areas the assessment of future strategies will continue to be difficult. However, as explained, we foresee a change of strategy within five years anyway, and later perhaps even no badger control. We also believe that our proposals in paragraphs 139 and 140 below, involving a more critical assessment of data already available, may preclude the need for an additional intensive field study.

Distribution and incidence of disease in badgers

135. To confirm our hypothesis that the disease in badgers is widely but sparsely distributed across the country, it would be necessary to sample a large number of badgers in many areas. If such sampling was conducted while no live test was available it would mean that a great many badgers would have to be killed for *post mortem* and laboratory examinations. We do not consider that the need for this research is so urgent that it cannot await the development of a diagnostic test for bovine tuberculosis in living badgers. When such a test is available, information on the distribution and incidence and prevalence of disease can be obtained without having to kill the animal. In the meantime we recommend that the Ministry continues, through publicity, to encourage members of the public to notify them of the location of badger carcases as this at least provides some indication of the disease status of badgers outside the areas subject to badger control.

Distribution and density of badger populations

136. We have mentioned the initiatives taken by the Universities of Exeter and Bristol, and the Mammal Society of the British Isles to improve the data on the distribution and density of badger populations. More precise data on these aspects would enable the Ministry to be even more certain that their operations were not a threat to the badger population as a whole. It would also provide a base on which future judgements might be made. We therefore recommend that the Ministry encourages such initiatives, perhaps with some financial support.

Ageing of badgers and their reproductive biology

137. Two aspects of badger biology relevant to the tuberculosis problem are still inadequately understood. These are the reproductive biology of the badger, and the relationship between the age of badgers and the incidence of the disease. The significance of reproductive biology is that there appears to be some restraint on breeding which might explain the slow rate of population growth, and possibly the lack of mobility, when compared with many other mammals. A method of being able to age badgers accurately, would also allow for more detailed analysis of the prevalence of infection in different age groups of the badger population, and thus shed light on the transmission of the disease. Although these aspects could have implications for a future strategy, we recognise that they are perhaps more of a basic scientific nature, and thus less appropriate for priority funding by the Ministry. However we do note that all badgers taken in Ministry operations or handed in by the public are subject to *post mortem* laboratory examination, and we do not believe that sufficient use is made of the available material in the context which we are now discussing. We also acknowledge that, because of the high standards of health and safety required for laboratories working on potentially infected badgers, there may be problems in making the badger carcases available to scientists from institutions other than the Ministry in order to conduct this research. However we recommend that the Ministry should seek ways of obtaining this information from the material which comes into their hands.

Modelling and statistical studies

138. Lack of critical information has represented a major constraint on our ability to undertake our review with the precision we would have wished. It has limited our attempts to assess the long term development of the problem with respect to bovine tuberculosis and badgers, to evaluate the success of badger control over the past 10 years, to identify potentially relevant strategy alternatives and to predict their likely impact in operation. The Ministry now collects a wide array of data derived from its field and laboratory operations and assembles these via computers into an accumulating database. While this should serve well the needs for monitoring the changing situation over time, we see a requirement for more specifically oriented analyses in two broad areas of enquiry.

139. The first relates to the modelling of detailed processes affecting tuberculosis within the badger population and its transmission to cattle. The only research of this type of which we are aware was conducted under a Ministry contract at Imperial College. Conventional experimental data on the progress of infection within, and its impact on, badger social groups of different sizes, and on the total badger numbers in a given region under different conditions of population density, are unobtainable and will always remain so. Similarly, as we have said, even the introduction of "no badger interference zones" would be insufficient to yield adequate data on the probabilities of badger-to-cattle transmission within any given time period under different conditions of management, cattle and badger population and infection levels. Furthermore, the length of time necessary for changes to reveal themselves under natural conditions and to be measured with confidence means that understanding accumulates only slowly after many years. Under such circumstances, mathematical modelling has become an accepted and potentially powerful device for exploring alternative possible patterns of change under carefully specified assumptions, and in simulating the implications and likely consequences of different interventions in the system under study. The development of such models would be dependent on the understanding of such diverse aspects as disease epidemiology, badger ecology and behaviour, farm management, and spatial aspects of badger-cattle interaction. The accuracy of the predictions depends heavily on the availability and quality of data to allow adequate empirical specification of the mathematical models constructed. Our earlier proposals for research are directed towards the accumulation of just such a database, and we recommend that additional resources are allocated for a limited number of appropriate studies designed to exploit such data with a modelling approach. We feel such research would be highly cost-effective in the present situation of knowledge.

140. Secondly, we believe that attention should now be given to statistical studies designed to elicit and explain the observed time paths of tuberculosis incidence in cattle herds on a national and appropriate regional basis. We have ourselves made a limited attempt at such work, as reported in Appendix 11, and the related work of a Ministry epidemiologist is reported in Appendix 12. While a detailed understanding of the disease problem is desirable at the "micro" level of the badger social group and the farm (paragraph 139), it remains the case that strategies are designed, implemented and assessed on a broader and more aggregated basis. We recommend that the assembled and accumulating data series on the incidence of herd breakdowns over time within and across relevant regions of the country be subjected to detailed statistical analysis in an attempt to identify, more definitively than we have been able to do, the underlying trends under both controlled and uncontrolled conditions. As we have explained in Appendix 11, despite the analyses conducted already there remains great uncertainty over the correct explanation for the observed pattern of incidence, both at the national level and within south west England. Particularly in the latter region, it is unclear whether the incidence of breakdowns has been declining over the long term, whether the underlying trend is static, or whether there exists evidence of a threat of a serious upsurge in herd breakdowns. Carefully constructed statistical models, using aggregate and partial data, could do much to clarify the true situation, and to assess the confidence that can be placed in different explanations of the observed pattern. With the results of such studies it should be possible to assess more completely the success of the past control strategy, and to predict the likely consequences of any modified strategy.

Cost of research

141. We have given some indication of the likely level of costs of some elements of the progremme of research which we are recommending. Estimates for the other elements will have to await more detailed specification of what can be done. If our proposed interim strategy for badger control is taken up, some resources should be released for use on this research programme. It is also the case that much of the recommended research focuses on the badger itself. Therefore it could reasonably be expected to progress through the support of conservation interests rather than being dependent solely on the agriculture budget. We recommend that the Ministry pursues alternative sources (both governmental and non-governmental) of funding for elements of this research programme.

Who should undertake research?

142. We have recommended already that the Ministry should consider whether different laboratories could best undertake the work on the different stages in developing a diagnostic test for bovine tuberculosis in living badgers. We have also recognised that, because of the difficulty in working on potentially infected badgers, there may be problems in institutions, other than the Ministry, conducting some aspects of the research programme. However, we also believe that the Ministry should consider whether other institutions and laboratories would be better equipped to carry out other aspects of the research; this approach may be more cost effective.

Future review

143. With the flow of additional data becoming available from both the research which we have recommended and the routine badger removal operations, it is impossible to specify a date at which the policy and strategy on bovine tuberculosis and badgers should next be reviewed. Obviously we would expect a change in strategy if a diagnostic test in living badgers becomes available, or clear evidence of an unacceptable upsurge in the level of herd breakdowns begins to emerge. However, other than that, we believe that it is best left for the Ministry to keep the policy and strategy under continuous review.

CHAPTER 10

RELATIONS WITH THE PUBLIC

The role of the Consultative Panel on Badgers and Tuberculosis

144. The Panel was created in 1975 with the following terms of reference:—

"To keep under review:—

(1) the evidence relating to bovine tuberculosis in badgers, including its incidence and its relationship to bovine tuberculosis in cattle; and

(2) The operations to be undertaken by the Ministry in order to eradicate bovine tuberculosis from badgers and to monitor its existence in the badger population."

A list of the organisations represented on the Panel is included at Appendix 13, and in addition the membership includes individual experts in the field. The Panel as a whole has met three or four times a year and, additionally, local members, forming a mini-Panel, have met in south west England as the occasion demanded to discuss with Ministry officials badger investigations that are outside the normal pattern.

145. The Ministry has acknowledged publicly the value of the advice given by the Panel, and when we met the Panel the members indicated that they felt they were fulfilling a useful role and had had some impact on the policy, its implementation, and associated research. It cannot have been easy for the Panel to arrive at co-ordinated advice on the many aspects of the problem, given the spectrum of views represented on it. Good sense and an appreciation of the views of others must have been shown on all sides for satisfactory compromises to be reached. This very ability to reach compromises has brought upon Panel members, particularly those representing conservation interests, criticism from extremists who seem to regard any compromise as rubber-stamping the Ministry's policy. However this appears to be a minority view and we agree with the majority who regard the Panel as a valuable forum. Therefore we recommend that it should continue. The Panel's terms of reference should be amended to reflect what we regard as a reasonable objective for the policy, see paragraph 106, rather than the current stated objective of eradicating bovine tuberculosis from badgers.

146. A number of detailed suggestions have been put to us on the composition of the Panel mainly recommending the addition of an epidemiologist and a statistician, the detail and confidental treatment of papers circulated by the Ministry to Panel members, and the public reporting of the Panel's meetings. On the face of it there appears to be merit in all these suggestions, but we recognise there will be limitations to the extent to which they can be implemented. For instance, there are likely to be conflicts between the requirement for greater detail in Panel papers and any easing in the confidential treatment of those papers, particularly if they include details of individual farms. Also it is normal for the detailed discussions of such advisory groups to be regarded as confidential even though their final advice might be made public. We feel that the Panel itself, in discussion with the Ministry, is best placed to consider these detailed issues and we therefore make no firm recommendations on them. However, we note that these detailed suggestions have emanated from, *inter alia,* groups whose membership includes members of the Panel. This perhaps provides an indication that Panel members may feel inhibited in putting forward such suggestions at Panel meetings. We therefore recommend that, in addition to discussing the suggestions mentioned earlier in this paragraph, the Panel and the Ministry also consider if the structure of their meetings could be changed so that such suggestions might come forward more readily.

The role of liaison officers

147. As a result of one of Lord Zuckerman's recommendations, the County Naturalists' Trusts in the counties affected by the problem appointed officers "to liaise with the Ministry's veterinary staff with the responsibility of keeping themselves informed about official operations against badgers, and of communicating with interested conservation groups". We sought comments from all such liaison officers and, from those that replied, received a variety of views. In some counties the liaison was reported to be satisfactory but we sensed a feeling that whilst the Ministry was prepared to provide information on request, where confidentiality permits, it was less ready to volunteer information. We feel that, if such liaison is to be fully effective, the Ministry must make every effort to keep the liaison officers informed of relevant events. We detected also a reluctance on the part of some liaison officers to, as they put it, "defend the Ministry's position" to other organisations. We would stress that the role of liaison officer is to serve as a two-way communication link, not to act as an advocate for either side. There are advantages to the County Naturalists' Trusts, in terms of being appraised of everything that the Ministry discloses on the subject, as well as to the Ministry, in terms of clear lines of communication and efficient use of resources, and for there to be as far as possible only one channel of communication locally between the Ministry and conservation interests. The line between passing on information supplied by the Ministry and "defending their policy" may indeed be a thin one. However we believe that the liaison officers should recognise clearly the value of this role in communicating with the County Naturalists' Trusts and other conservation organisations, and we hope that they will feel able to do so objectively.

148. A recent feature on the liaison front is the funding by the World Wildlife Fund—UK of a liaison officer post for the whole of south west England on a half-time basis for one year. The post was filled in 1985 and we understand that the occupant is using the year's funding to see if there is likely to be a continuing role for such a post. It is not possible to make a judgement on the usefulness of such a post until its role is fully defined. We

must leave it to others to make such a judgement when the trial is completed and in the light of any implementation of our recommendations. However if such a post was to be made permanent we see it as essential that the postholder should be equally acceptable to conservation and to farming interests, and to have the confidence of the Ministry. The funding of the post might have to be reconsidered and there might be a role for the Consultative Panel on Badgers and Tuberculosis in setting objectives for, and monitoring the progress of, the postholder.

The media and public relations

149. In paragraphs 54 and 147 we have touched on criticisms of what is perceived as a lack of a positive approach to public relations by the Ministry. Others, both opponents and supporters of the Ministry's policy, have been even more severe in their criticisms. Opponents of the policy criticise the lack of information issued by the Ministry and in some cases even suggest that what is issued is intentionally inaccurate or misleading. We have found nothing to substantiate the latter allegations. On the other hand supporters of the policy criticise the Ministry for not reacting to what they regard as unsubstantiated and emotional assertions in the media, either in articles or published correspondence from organisations or individuals. We recognise that the Ministry is constrained by the need to maintain the confidentiality of information about individual farms, and that this can be an inhibiting influence on the details it can make available publicly. It is also the case that any response by the Ministry in the media is likely to have less impact than the original, usually less constrained, item. Having said that, the Ministry has been implementing a policy that had entirely defensible objectives based on the information available, and we have seen no evidence to suggest it was doing this other than earnestly and with care. In the light of that, we do feel that it could have done more to put its side of the case publicly in order to aid the wider public understanding of a very difficult situation. It is not easy to recommend any specific methods of improving on this performance as each situation that arises may require different treatment. However we recommend that the Ministry adopts a more positive approach to public relations by thinking of what information it can release and explanations it can offer rather than of what it cannot. We leave the detailed consideration of this to the Ministry but our tentative suggestions would be for the more frequent use of press releases and perhaps for the occasional press conference which would provide an opportunity for a presentation of aspects of the policy in some depth. We must also emphasise that the provision of more detailed information by the Ministry on individual badger operations will place a responsibility on those who receive it. If the release of such information is abused, the Ministry could not be blamed for withholding details in other cases.

150. An associated matter is the Ministry's apparent reluctance to participate in public discussions of the problem. It is possibly for this reason that they have had to suffer accusations that they were anti-badger and concerned only with maintaining control operations. This is particularly disquieting in the context of scientifically-based meetings and seminars. We recognise that Ministry researchers employed on individual aspects of the policy might not have an overall view of the subject. Indeed the very fact that they are carrying out relevant research could mean that they may not support the policy fully and this could be a potential cause of embarrassment. However it remains the case that most of the research relevant to the problem is conducted by the Ministry and therefore if the Ministry's researchers are precluded from participating in discussions there will be little opportunity for informed consideration of the problem elsewhere in the scientific community. On balance we feel that the Ministry has more to gain by participating in such discussions than by opting out to avoid possible embarrassment to both the Ministry and its staff.

151. If the Ministry responds positively to our recommendations in this chapter, the public should appreciate better the dilemmas inherent in the current situation and become aware of important developments as they occur. However, we still see a role for the Ministry's reports on "Bovine Tuberculosis in Badgers" in drawing together developments and setting them in context. We recommend that the Ministry continues to publish these reports on an annual basis, at least for the duration of the interim strategy.

CHAPTER 11

SUMMARY OF RECOMMENDATIONS

We recommend that:—

Objective of policy

(i) the objective of the policy on bovine tuberculosis and badgers should be to limit the transmission of disease from badgers to cattle by dealing with identifiable and avoidable risks, quickly and effectively at a reasonable cost (paragraph 106);

Future policy and strategy

(ii) when a diagnostic test in living badgers is available, the procedures for badger control be changed to discriminate between infected and healthy badgers (paragraph 118);

(iii) with the flow of additional data becoming available from research and badger removal operations, the Ministry keeps the policy and strategy on bovine tuberculosis and badgers under continuous review (paragraph 143);

Interim strategy for badger control

(iv) for the time being, action should be taken against badgers only after a herd breakdown, for which no other source of infection can be found, in areas of the country where there has been a recent history of herd breakdowns which have been attributed to infected badgers (paragraphs 108 and 109);

Operation of interim strategy

(v) in such circumstances as defined in recommendation (iv), the badgers using that part of the breakdown farm where it is believed that the disease was transmitted to cattle, or the whole farm if it is not possible to be more precise, should be captured, killed humanely and examined *post mortem*, without prior sampling or delineation of social groups, and with no question of extending the operation beyond the breakdown farm (paragraph 110);

(vi) in the context of these more limited badger removal operations, the current practice of releasing lactating female badgers should be discontinued (paragraph 111);

(vii) the Ministry undertakes the necessary consultations with a view to placing before Parliament a revision of the Badgers (Control Areas) Order 1977, with statutory Control Areas in which (a) there has been a recent history of herd breakdowns attributed to infected badgers and (b) the Ministry would propose to undertake badger removal operations automatically in the advent of future otherwise unexplained herd breakdowns (paragraph 112);

(viii) outside of the revised statutory Control Areas, the Ministry should consider taking action against badgers only after (a) two or more otherwise unexplained herd breakdowns have occurred in close proximity and (b) seeking the advice of the Consultative Panel on Badgers and Tuberculosis (paragraph 109);

(ix) the Ministry keeps the interim badger control strategy under continuous review, and, in particular, reconsiders it if (a) no infection is found in the badgers removed in a significant number of cases, or (b) there is evidence of a significant increase in herd breakdowns (paragraphs 110 and 113);

(x) the Ministry continues to undertake by the use of live trapping such badger operations as are justified, and provides adequate resources to ensure that operations are undertaken with the minimum of delay (paragraphs 114 and 115);

Other action to reduce risk of disease transmission

(xi) the Ministry encourages farmers to seek to prevent (a) cattle having access to badger setts and (b), as far as possible, badgers and cattle eating from the same food source (paragraph 126);

Research needs

(xii) with a view to discriminating between healthy and infected living badgers in any future badger operations and as an aid to other research, the Ministry should transfer resources from other areas of the programme to seek to speed progress in developing a diagnostic test in living badgers, and consider using different laboratories for the different stages of the work (paragraphs 119 and 120);

(xiii) the field studies of badger population biology and transmission of tuberculosis being undertaken at the Ministry's Gloucestershire study area should continue for at least another five years. The facilities there be made adequate for such work to be developed and conducted effectively. In the event of a herd breakdown in the study area, adequate compensation terms be available to the farmer(s) concerned so that the continuance of the programme can be ensured (paragraph 132);

(xiv) the Ministry seeks ways of obtaining information about the reproductive biology of the badger and the relationship between the age of badgers and the incidence of the disease, from the badger carcases which become available to them (paragraph 137);

(xv) the Ministry allocates additional resources to develop modelling studies of the epidemiology of tuberculosis within badger populations and its transmission to cattle (paragraph 139);

(xvi) the Ministry undertakes further statistical studies designed to elicit and explain the observed time paths of tuberculosis incidence in cattle herds on a national and appropriate regional basis (paragraph 140);

(xvii) the Ministry pursues alternative sources to the agriculture budget for the funding of elements of the research programme on bovine tuberculosis and badgers (paragraph 141);

(xviii) the Ministry considers if aspects of the research programme on bovine tuberculosis and badgers could be effectively conducted by other institutions and laboratories at a lower cost than if they were conducted "in house" (paragraph 142);

Information needs

(xix) the Ministry makes available adequate resources to allow collection and analysis of the data arising from the interim badger control strategy (paragraph 114);

(xx) the Ministry continues, through publicity, to encourage members of the public to notify them of the location of badger carcases (paragraph 135);

(xxi) when a diagnostic test in living badgers is available, sampling be undertaken throughout the country to seek more detailed evidence of the distribution and incidence of tuberculosis in badgers (paragraph 135);

(xxii) the Ministry encourages initiatives to improve the data on the distribution and density of badger populations, perhaps with some financial support (paragraph 136);

(xxiii) the Ministry continues to take such opportunities as arise to examine wildlife, other than badgers, for tuberculosis, and particularly continue with their investigations into the possibility that there may be a reservoir of the disease in deer in parts of the country (paragraph 42);

Relations with the public

(xxiv) the Consultative Panel on Badgers and Tuberculosis be kept in being, but that its terms of reference be amended to reflect the objective of the policy set out in recommendation (i) (paragraph 145);

(xxv) the Ministry and the Consultative Panel consider jointly whether any changes could be made usefully to (a) the Panel's composition, (b) the detail and confidential treatment of Panel papers, (c) the structure of Panel meetings and (d) the public reporting of the Panel's meetings (paragraph 146);

(xxvi) the liaison officers appointed by the County Naturalists' Trusts develop their role as a two-way channel of communication between the Ministry and conservation organistions on this subject. The Ministry make all the efforts that it can to keep those liaison officers informed of relevant events (paragraph 147);

(xxvii) the Ministry adopts a more positive approach to informing the public on this subject, perhaps by the more frequent use of press releases and press conferences (paragraph 149);

(xxviii) the Ministry participates in public discussions of the problem, particularly in scientifically-based meetings and seminars (paragraph 150);

(xxix) the Ministry continues to publish editions of their series of reports on "Bovine Tuberculosis in Badgers" on an annual basis, at least for the duration of the interim strategy (paragraph 151).

SUMMARY OF ACTION TAKEN SUBSEQUENT TO LORD ZUCKERMAN'S REPORT

(The comments made on research and development work are listed for ease of reference under the headings provided by Lord Zuckerman's recommendations. However it is important to recognised that, in the majority of cases, the projects referred to represent natural progress in long-standing research projects and not new tasks undertaken since 1980).

RECOMMENDATION 1 THAT CONTROL OPERATIONS IN THE AFFECTED AREAS, INCLUDING GASSING, BE RESUMED AS SOON AS POSSIBLE, AND THAT THEY CONTINUE TO BE MONITORED NOT ONLY TO DISCOVER WHAT EFFECT THEY HAVE ON THE OUTBREAK OF TB IN CATTLE BUT, IN ADDITION, AND EQUALLY IMPORTANT, ON THE PREVALENCE OF THE DISEASE IN BADGERS.

1980–81

Badger control operations by gassing were resumed in November 1980. The prevalence of infection in badgers was determined through sampling areas where concomitant badger and cattle infection was suspected and from examining casualties reported by the public.

At Steeple Leaze recolonisation was monitored following earlier gassing, while at Thornbury the area was maintained badger free until the end of the year.

1982

The Minister banned gassing as a means of control with effect from 26 June but, following consultations with the Consultative Panel, control by capture was approved in August. The changeover from gassing to capture coincided with the development of methods which permitted a more accurate determination of social groups and their territories than had previously been possible. As a result, knowledge of the prevalence of infection in badgers within control areas was improved. Strategies were developed with the aim of determining the prevalence of infection within individual social groups and of determining the geographical limits of local infection.

Operational data was entered on a micro computer from May.

The monitoring of recolonisation continued at Steeple Leaze and no TB was identified in a sample of badgers taken for disease examination. At Thornbury recolonisation took place slowly.

1983

Information on the prevalence of infection in badgers continued to be obtained from two sources: official investigations and carcases notified by the general public. Where official investigations led to approved Badger Removal Operations, information was obtained on the prevalence of infection in the social groups of badgers that were trapped out. During the year, current and retrospective data was entered on microcomputers locally and was available for operational purposes. Monitoring at Steeple Leaze continued until November when it became necessary to deploy the team elsewhere. Monitoring at Thornbury was at a reduced level following staff transfers in March. It is intended to continue monitoring, at both sites but only intermittently from now on. The experimental areas continued to be free of identifiable infection in both badger and cattle. A national computer system to record and analyse the results of, and activities involved in, badger investigations, badger removal operations and the post mortem and bacteriological findings of all badgers examined was developed.

1984

Information on the prevalence of infection in badgers continued to be obtained from official investigations and national survey results. The national computer system came into full operation and current and certain historical data was entered on the system. The data will be used to analyse the effects of the control policy on the prevalence of disease in cattle. Monitoring of badger recolonisation at Steeple Leaze and Thornbury continued although at reduced levels. No outbreaks of disease in cattle occurred at Thornbury, although a single outbreak occurred just north of the Steeple Leaze project area.

Mathematical modelling has proved to be a valuable means of predicting events in the current rabies epidemic in Europe. Prof Anderson of the Imperial College London who had considerable expertise in this field is collaborating in a study of the population dynamics of badgers. In 1982 this project was extended to consider the dynamics of TB infection in badger populations. The project is now completed and a paper has been accepted for publication in *Phil. Trans. Roy. Soc.* in 1985.

RECOMMENDATION II THAT AN EFFORT BE MADE TO DISCOVER HOW PREVALENT TB IS IN THE BADGERS OF COUNTIES CONTIGUOUS WITH THE AREAS NOW AFFECTED.

1980–81	1982	1983	1984
The prevalence of infection in badgers in parts of the South West where badger control operations are not undertaken is determined by examination of carcases submitted or notified by members of the public. There is no alternative means of assessing this without killing and autopsy of badgers. In the South West although infection has been identified in this sample the prevalence is very low.			
	Mathematical modelling of badger population dynamics and the effects of *M.bovis* infection will aid in the assessment of significance of the findings of the National Survey.	In 1983 infected badgers were only identified in counties where the infection in badgers had been demonstrated previously.	In 1984 infected badgers were again confined to counties where infection in badgers had been demonstrated previously.

RECOMMENDATION III THAT EXPERTS FROM THE GOVERNMENT'S CHEMICAL DEFENCE ESTABLISHMENT BE CALLED IN TO DEVISE IMPROVEMENTS IN THE GASSING PROCEDURES THAT HAVE BEEN USED HITHERTO.

	Work carried out by the Government's Chemical Defence Establishment on gassing procedures cast doubt on the speed of action and humaneness of gassing badgers and the technique was discontinued in 1982.		

RECOMMENDATION IV THAT STEPS BE TAKEN TO REDUCE THE LENGTH OF THE INTERVAL THAT SEPARATES A DECISION THAT BADGERS ARE INVOLVED IN A HERD BREAKDOWN FROM THE START OF CONTROL OPERATIONS

Where concomitant infection in cattle and badgers was demonstrated, farmers within badger control operational areas were naturally concerned if their herds continued to be at risk from infected badgers. This concern had to be balanced against the land-owners, Nature Conservancy Council, Water Boards and other bodies need to be fully informed of proposed actions before they took place. The administrative procedures were urgently examined to determine where they could be speeded up and some progress was made.	The development of the new strategies for badger control reduced administrative procedures to a minimum. Nevertheless, delays in establishing that badgers were the origin of infection in cattle, and then in their control, continued due to shortages of resources.	The new strategies enabled Badger Removal Operations to start immediately after infection in badgers had been demonstrated. However, delays continued to occur with Preliminary Badger Investigations (PBIs) due to continuing shortages of resources. Additional operational teams were recruited at the end of the year to tackle the backlog.	The additional operational teams recruited in 1983 enabled PBIs to commence more promptly. The length of time between the request for a PBI being made and its commencement could be monitored through the badger computer system.

RECOMMENDATION V THAT IN ADDITION TO BADGERS WHICH ARE SUSPECTED OF BEING ASSOCIATED WITH A HERD BREAKDOWN, OTHER WILD CREATURES SHOULD BE SYSTEMATICALLY SAMPLED AND EXAMINED FOR TB.

1980–81	1982	1983	1984
An investigation of the potential role in the spread of *M.bovis* of wildlife species other than *Meles meles* was commenced in East Sussex, in an area of known badger infection, during the Autumn of 1981. This medium term study was completed in Summer 1984. No species other than the badger was found to be infected with *M.bovis* in this area.	In May 1982 an investigation was initiated in the South West of England to provide data on the causes of mortality in ferrets. This investigation augments the East Sussex project and the ad hoc studies reported in the Journal of Hygiene and in Lord Zuckerman's Report. At the same time an investigation was undertaken into the possible involvement of mink in the tuberculosis story in West Wales. *M.bovis* infection has not been diagnosed in either study. Investigations continue in ferrets although the response from the general public has been very poor.		In May 1984 in Wiltshire *M.bovis* was isolated from a roe deer, *Capreolus capreolus,* showing lesions of tuberculosis at post mortem examination. A study is underway to estimate the population density of deer in areas of the South West where infection has been found in cattle and badgers and a survey of culled deer for evidence of *M.bovis* infection in those areas is also being undertaken.

RECOMMENDATION VI THAT THE ACTUAL TIMING OF INDIVIDUAL GASSING OPERATIONS BE CAREFULLY CONTROLLED.

It was found to be impractical to follow this recommendation and no action had been taken up to 26 June 1982 when gassing was prohibited. The interval between the identification of infection and eventual gassing was already considered to be too long and if the staff had waited for the most advantageous time of the year the interval would have been even longer. Also the staff would have been overwhelmed by the number of operations they would have been expected to undertake in a concentrated period.

RECOMMENDATION VII THAT THE PUBLIC IN ALL PARTS OF THE COUNTRY BE REMINDED OF THE NEED TO INFORM MINISTRY OFFICIALS OF ROAD CASUALTIES OR OF THE PRESENCE OF DEAD BADGERS EITHER IN WOODLAND, PASTURE, OR FARM-LAND, SO THAT THEY CAN BE TAKEN FOR EXAMINATION TO THE STATE VETERINARY CENTRES.

In addition to national publicity, members of the Pests and Veterinary Services have reminded the general public, including members of the various conservation bodies, of the desirability of reporting dead badgers.

National publicity on radio and in "current topics" continued.

National publicity on radio and in "current topics" began in May 1981. The response by the public to the publicity more than doubled the figures of carcases for GB compared to the figures for 1980.	The increase in the numbers of carcases reported by the public continued and was up by half as many again over the 1981 figure. Arrangements have been made with British Rail Southern Region to notify the location of badgers electrocuted on the third rail system.	The increase in the number of carcases reported by the public continued but was not as great as in 1982. The Forestry Commission have issued instructions to their staff to notify the location of any dead badger found.	National publicity continued. The number of carcases reported by the public increased slightly over 1983.

RECOMMENDATION VIII THAT LAND-ENGINEERS AND OTHER SCIENTISTS WHO MIGHT HAVE IDEAS RELEVANT TO THE PROBLEMS SHOULD BE CONSULTED BY MAFF OFFICIALS ABOUT MEASURES TO PREVENT RECOLONISATION OF CLEARED SETTS AND LOCALITIES.

1980–81	1982	1983	1984
	Earlier data on various traditional methods such as blocking holes and the use of alleged repellants were re-examined but none looked sufficiently promising to indicate further work.	The prevention of recolonisation of cleared setts seems to be a more realistic goal than prevention of recolonisation of cleared localities. Discussions with Panel members and others indicated that trials with electrified fences and balled-up wire-netting should be undertaken. Preliminary discussions with land engineers in the Land and Water Service of MAFF did not produce substantive proposals, the possibility of the use of a rapidly hardening foam compound in empty setts was one possibility. The use of endoscopes to determine occupation of setts has been considered. Some preliminary trials with electrified fencing have been undertaken, a project on evaluation of repellents is in hand. Changes of scientific staff in the Wildlife and Storage Biology Service, a considerable re-training programme commitment, and pressure of operational cases has limited time available to pursue these ideas.	Trials are underway to assess the effectiveness of repellants to deter badgers causing damage to buildings, crops etc in urban and rural areas. These results may be applicable to the badger TB work.

RECOMMENDATION IX THAT THE CONSULTATIVE PANEL ON BADGERS AND TUBERCULOSIS BE KEPT IN BEING TO ACT AS A CENTRAL FORUM OF ADVICE.

The Panel has been kept in being and has continued to meet regularly.

RECOMMENDATION X THAT IN THE COUNTIES AFFECTED, OFFICERS BE APPOINTED BY THE COUNTY NATURALISTS' TRUSTS TO LIAISE WITH THE MINISTRY'S VETERINARY STAFF WITH THE RESPONSIBILITY OF KEEPING THEMSELVES INFORMED ABOUT OFFICIAL OPERATIONS AGAINST BADGERS, AND OF COMMUNICATING WITH INTERESTED CONSERVATION GROUPS.

Liaison officers were appointed by each of the County Trusts for Nature Conservation in the South West. Meetings between the liaison officers and the Veterinary Service have been held. In addition, the wildlife and storage biologists have regular contact with officers of the County Trusts on a number of wildlife issues.		A regional meeting for the county representatives of the Naturalists' Trusts and Nature Conservancy Council in the South West was held in October. Formal and informal meetings were also held at a local level.	A regional meeting for the county representatives of the Naturalists' Trusts and Nature Conservancy Council in the South West was held in May. Formal and informal meetings continued at local level.
	The County Naturalists' Trusts for Staffordshire, Surrey and Sussex appointed liaison officers.	The County Naturalists' Trust for Cumbria appointed a liaison officer.	

RECOMMENDATION XI THAT IN THE AFFECTED COUNTIES THERE SHOULD BE A FREER EXCHANGE OF INFORMATION ABOUT HERD BREAKDOWNS BETWEEN MAFF VETERINARY STAFF AND VETERINARY SURGEONS IN PRIVATE PRACTICE.

Annual meetings have been held in each county in the South West and at these, veterinary surgeons in practice were informed about the tuberculosis situation. Outside of these meetings there has been regular contact and discussion with the practices.

RECOMMENDATION XII THAT IN THE HOPE THAT KNOWLEDGE SO GAINED WILL HELP IN ALL ASPECTS OF THE CONTROL PROGRAMME, FIELD-WORK ON THE BEHAVIOUR OF BADGERS IN GENERAL SHOULD CONTINUE TO BE ENCOURAGED IN THE SAME WAY AS DECISIONS ABOUT THE EXTENT OF GASSING OPERATIONS SHOULD TAKE INTO ACCOUNT ALL THAT CAN BE LEARNT LOCALLY ABOUT THE MOVEMENT OF BADGERS.

1980–81	1982	1983	1984
Whilst SW regional staff were not able to undertake much field work on aspects of behaviour of badgers, account was taken, in deciding the extent of gassing operations, of the information on movements of badgers collected by Agricultural Science Service staff during bait marking and removal operations in various parts of the region.	The development of new control strategies stimulated field work on bait marking and demarcation of social group boundaries. Behaviour towards cage traps was studied briefly.	Bait marking results have been variable throughout the year and from locality to locality as expected. Proposals on testing efficiency of identifying social group boundaries with and without bait marking have not been possible because of staff changes in the Wildlife and Storage Biology Service, it is still intended to do this. A project proposal to study the behaviour of trapped animals is being developed. Work is needed on the identification of badgers opening blocked setts after removal has taken place and the effect on territory boundaries and social group composition, and the interaction between contiguous social groups after samples have been taken. Work is also needed to show what effects the removal of a social group has on the composition and territory size of a contiguous group. Information on badger sett density and distribution will be extracted during operational work.	Some work has been done in S.W. Region on testing the efficiency of identifying social groups without bait marking. Results are currently being assessed but more work will probably be needed before conclusions can be reached. Some ad hoc observations have been made on lactating sows in connection with reopening setts but no systematic work has been possible. Pressure of operational work has limited the amount of research work that WSB staff have been able to undertake.
The ecology and behaviour of badgers continued to be studied at the Gloucestershire study area; the research programme being redirected towards the study of disease aspects. The distribution and progression of TB in the badger population was investigated by faeces sampling, whilst infection within selected social groups was followed by clinical examination of individual badgers. A start was also made on the assessment of factors determining the exposure of cattle to infection, including badger behaviour and environmental contamination by infective badgers.	Studies continued. Cattle and badger behaviour studies are being undertaken by a post doctoral research student at Reading University. It is intended that this work should identify the possible points of interaction between the species. A Co-operative Award in Science and Engineering studentship was established to consider badger population density and geographical distribution in SW England. An observation of badgers in East Sussex, an area of known badger infection well away from the South West problem areas, was commenced.	The cattle and badger behaviour project is nearing completion. Although a number of preliminary findings have emerged, conclusions are dependent on field studies now in progress. The project on badger population density and geographical distribution in SW England and observation of badgers in East Sussex are continuing.	Field work has now been completed and the project is being written up. The project on badger population density and geographical distribution in S.W. England is continuing. Observation of badgers in East Sussex has finished.
	Mathematical modelling of badger population dynamics and the effects of *M.bovis* infection will provide a valuable part of the research effort on the possible effects of TB infection on the behaviour of badgers and badger populations.		This project is now completed and a paper is due to be published in 1985.

RECOMMENDATION XIII THAT NO BADGERS WHICH LIVE IN AREAS WHERE THE PREVALENCE OF TB IS AS HIGH AS IT NOW IS IN PARTS OF THE SOUTH WEST BE MOVED TO OTHER AREAS: THAT IS TO SAY THAT 'TRANSLOCATION' BE FORBIDDEN.

1980–81	1982	1983	1984
	Amendments to the Badgers Act 1973 which were contained in the Wildlife and Countryside Act 1981 and brought into effect in February 1982 effectively outlawed translocation. All taking of badgers (except for tending injury), and hence their movement, is now subject to licensing by Agricultural Departments/NCC.		

RECOMMENDATION XIV THAT (A) INTERIM REPORTS OF THE PROGRESS OF THE CONTROL PROGRAMME SHOULD, IF POSSIBLE, BE PUBLISHED ANNUALLY: AND (B) THAT AN OVERALL REVIEW SHOULD BE CONDUCTED AT THE END OF THREE YEARS AND ITS RESULTS PUBLISHED, WITH ITS FOCUS ON CHANGES IN THE PREVALENCE RATE OF TUBERCULOSIS IN BADGERS, AS WELL AS ON THE NUMBERS OF HERD BREAKDOWNS.

(a) Annual reports on bovine tuberculosis in badgers have been published.

(b) An overall review of policy on badgers and bovine tuberculosis commenced in September 1984. The review team is chaired by Professor Dunnet of Aberdeen University.

Ministry of Agriculture, Fisheries and Food
(February 1985)

MINISTER'S STATEMENT TO THE CONSULTATIVE PANEL ON BADGERS AND TUBERCULOSIS ABOUT THE SUSPENSION OF THE USE OF GASSING AS THE MAIN METHOD OF BADGER CONTROL

The Rt Hon Peter Walker, MP, Minister of Agriculture, Fisheries and Food in a statement to a meeting of the Consultative Panel on Badgers and Tuberculosis in London on 1 July 1982, said:

"Shortly after I became Minister, I asked Lord Zuckerman to enquire into the whole question of tuberculosis in cattle and badgers and pending his report I suspended the gassing operations which had been taking place since 1975. Lord Zuckerman confirmed that badgers constituted a wildlife reservoir of tuberculosis from which cattle could be infected and stressed that the control of the disease was important for the health of the national cattle herd and also for the health of the badger. He recommended that gassing should be resumed and in conformity with that recommendation I announced in October 1980 that this would be done. Since that recommendation there has been further and powerful corroboration of the discovery of cross infection between badgers and cattle.

"Lord Zuckerman also recommended that further enquiries should be made about hydrogen cyanide in order to check what concentrations in the air of a sett would be needed to kill quickly and humanely.

"I ordered that such experiments should take place and I have recently received the results of these experiments. The results suggest that if badgers are to be killed in about one minute then 2000 parts per million of gas is needed in the air of the sett and that the corresponding figures for 5 minutes and 25 minutes are 882 parts per million and 194 parts per million respectively.

"These result are unexpected in the present state of informed opinion. They indicate that the response of the badger to cyanide is different from that of other animals such as rabbits. The reasons for this difference are not understood.

"The results do however imply that there must be doubt whether all the badgers in a gassed sett die quickly and therefore whether they die humanely. This is because the levels of gas secured in a sett, on which a report was made to you in 1979 (Third Report, Appendix 10 by the Ministry of Agriculture, Fisheries and Food on Bovine Tuberculosis in Badgers), are in general lower than the new experiments show to be required.

"The Welsh Secretary and I have therefore acted at once to suspend gassing as a means of badger control. All such operations ceased with effect from June 26. We shall continue control and experimental operations by trapping in those areas where trapping is already in use.

"When in 1975 the then Government secured legislation which allowed gassing to be legally employed as a means of badger control, their view that this was the most humane and efficient method of control reflected a consensus among scientists and was fully in line with the advice of the Home Office Independent Committee on Cruelty to Wild Animals in 1951. Their decision was taken after consultation with welfare interests and organisations, all of whom have since sent representatives to this panel.

"I wish to express my gratitude to Lord Zuckerman for having advised me to make further enquiries and experiments about hydrogen cyanide and it is on this advice that we have been able to take action to eradicate a practice that could cause suffering to badgers.

"It is necessary to consider urgently what alternative methods are available which can provide an effective and humane means of controlling tuberculosis in badgers. I shall wish to consult the Panel further on this matter and shall also be consulting all the organisations which have an interest."

STRATEGIES FOR BADGER REMOVAL OPERATIONS

1. This appendix describes the possible strategies for badger removal operations (BROs) which are deployed depending on the circumstances. The strategies (A, B, C, D and E) are shown in the flow chart.

2. Strategy A. If in-depth investigation fails to disclose an origin for disease in cattle, a full preliminary badger investigation is undertaken. If infection is found in badgers and approval is given for a BRO, under Strategy A the operation starts with the removal of infected social groups plus all contiguous social groups. Further infected social groups so discovered then lead to a further phase of the BRO with the removal of contiguous groups and so on until no infection is found in the badgers removed.

3. Strategy B is the same as Strategy A except in the extent of the initial removal operation. In Strategy B (used only for small farms ie those under 1 kilometre in any direction) in addition to the infected and contiguous groups, all other social groups using the infected farm are removed. Thereafter the operation extends to groups contiguous to those groups identified as infected under Strategy A.

4. In operational terms Strategy C is the same as Strategies A and B except that the preliminary badger investigation excludes the taking of samples of badgers' carcases or faeces. Historically the Ministry argues that there have been instances where sampling has failed to reveal any infection, but subsequent events such as the discovery of infected badgers following road traffic accidents and the occurrence of further outbreaks of tuberculosis in cattle with consequent further badger sampling, which has been positive, have shown that the veterinary officer's original opinion about the origin of the infection was correct. The use of Strategy C is designed to prevent such problems arising. It also has the advantage that BROs are able to start sooner than those operated under Strategies A and B as there is no need to wait until sample badgers have been caught, post-mortemed, cultured and found positive.

5. Strategy C is only used where:

(a) the farm history clearly indicates that infection, in cattle, has originated from badgers;

(b) tuberculosis in badgers is known to be endemic in the area; and

(c) the preliminary badger investigation survey confirms that the infected farm (or the part of the farm where the infection is suspected to have been contracted) is being used by badgers.

After consideration of the circumstances, the Ministry's Regional Veterinary Officer (South West region) may give formal approval for the commencement of the BRO and informs local members of the Consultative Panel (ie the mini-Panel). Following approval, those social groups whose territories impinge on the suspected pastures are removed. Thereafter, the sequence of events is the same as for other strategies. If infection is demonstrated in a social group the contiguous groups are also removed.

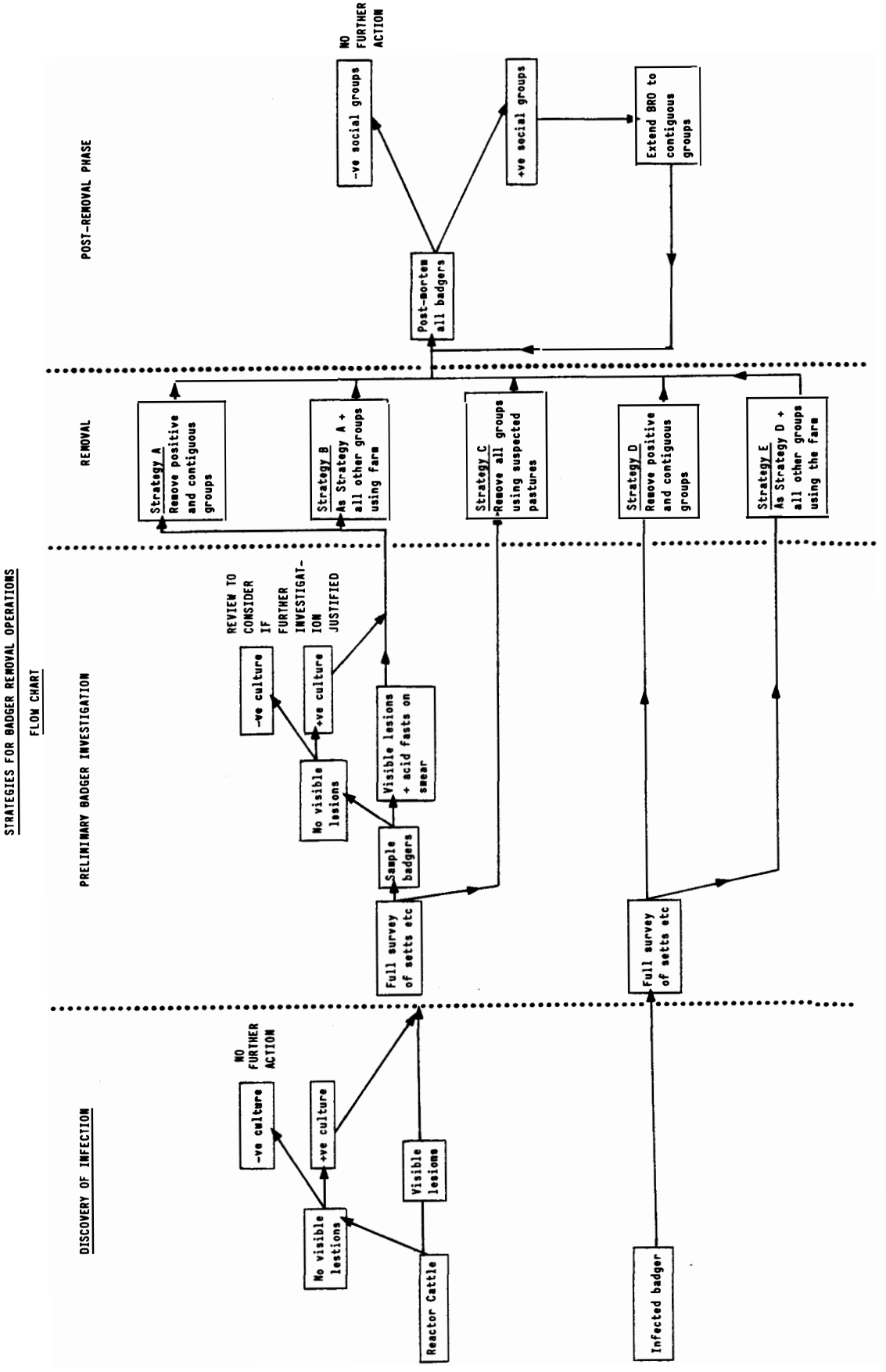
6. Strategies D and E. The Ministry further argues that the logical step which follows the policy decision to eliminate infected social groups of badgers where infection has also been concurrently confirmed in cattle and attributed to transmission from badgers is the elimination of infected social groups of badgers where they are detected prior to the occurrence of disease in cattle and are thought to be putting cattle at risk. Strategies D and E are essentially the same as Strategies A and B respectively, except that the preliminary badger investigation is initiated by the identification of an infected badger and not by the identification of infection in cattle. Following the discovery of an infected badger (eg a road traffic accident) cattle herds in the vicinity apparently at risk are tested. The case is discussed at one of the meetings that are held regularly to review the progress of preliminary badger investigations and BROs. A preliminary badger investigation is requested and this identifies the density of badgers in the area, their setts, ranges and defines more precisely the location and size of cattle herds at risk.

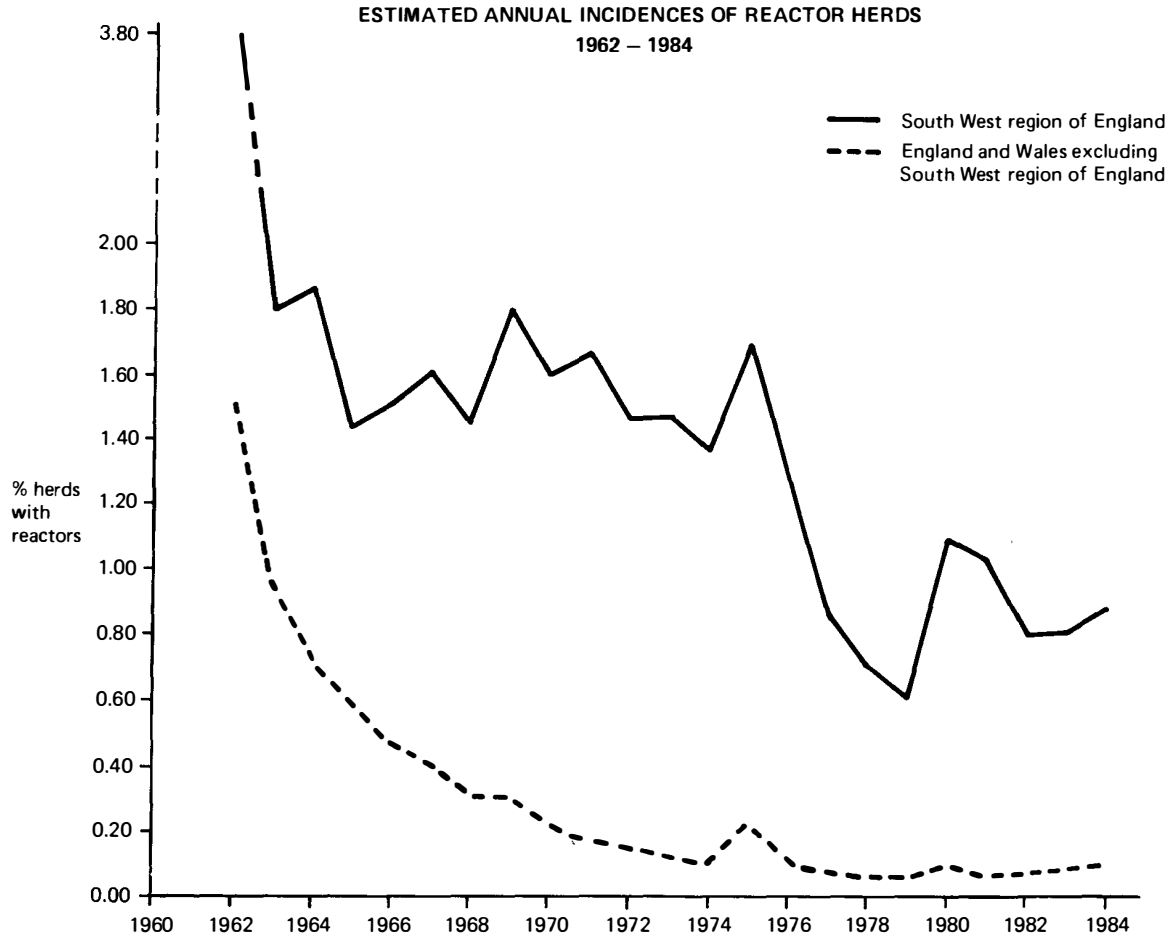
7. A recommendation to proceed with Strategy D or E is put to the mini-Panel where:

(a) cattle herds are considered to be at risk;

(b) it is possible to determine with reasonable certainty from which social groups the positive badger has originated.

After consultation with the mini-Panel, the Ministry's Regional Veterinary Officer may formally approve the commencement of a BRO.


STRATEGIES FOR BADGER REMOVAL OPERATIONS
FLOW CHART
DISCOVERY OF INFECTION
PRELIMINARY BADGER INVESTIGATION
REMOVAL
POST-REMOVAL PHASE
Reactor Cattle
No visible lesions
Visible lesions
-ve culture
+ve culture
NO FURTHER ACTION
Infected badger
Full survey of setts etc
Sample badgers
No visible lesions
Visible lesions + acid fasts on smear
-ve culture
+ve culture
REVIEW TO CONSIDER IF FURTHER INVESTIGATION JUSTIFIED
Strategy A Remove positive and contiguous groups
Strategy B As Strategy A + all other groups using fars
Strategy C Remove all groups using suspected pastures
Strategy D Remove positive and contiguous groups
Strategy E As Strategy D + all other groups using the fars
Post-mortem all badgers
-ve social groups
+ve social groups
NO FURTHER ACTION
Extend BRO to contiguous groups


ESTIMATED ANNUAL INCIDENCES OF REACTOR HERDS
1962 – 1984
South West region of England
England and Wales excluding South West region of England
% herds with reactors
3.80
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984

APPENDIX 5

ORIGINS OF TUBERCULOSIS INFECTION IN CONFIRMED HERD BREAKDOWNS: 1972 TO 1984

England, Wales and Scotland (excluding South West Region of England)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1972 to 1984	
														Total	%
Irish Cattle	58	23	22	23	22	12	13	9	1	6	9	3	1	202	39·8
Purchased Cattle	6	8	8	3	7	9	1	8	3	3	3	4	5	68	13·4
Contiguous Premises	0	12	4	0	1	1	0	0	0	0	0	0	1	19	3·8
Human	1	0	1	0	0	3	0	0	0	0	0	0	0	5	1·0
Miscellaneous	1	1	0	1	0	1	0	0	0	0	0	0	0	4	0·8
Badgers	1	0	1	3	0	1	1	3	5	3	5	1	2	26	5·1
Unknown	27	12	17	22	10	10	7	11	19	13	14	10	11	183	36·1
Total	94	56	53	52	40	37	22	31	28	25	31	18	20	507	100

South West Region of England

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1972 to 1984	
														Total	%
Irish Cattle	1	0	0	0	1	0	0	0	0	0	0	0	0	2	0·2
Purchased Cattle	8	11	7	12	8	5	9	2	11	11	8	6	11	109	8·9
Contiguous Premises	7	5	2	1	3	0	1	0	0	1	1	1	0	22	1·8
Badgers	33	53	51	51	62	50	24	40	57	79	64	56	44	664	54·1
Unknown	77	65	53	65	34	18	28	16	20	17	9	12	15	429	35·0
Total	126	134	113	129	108	73	62	58	88	108	82	75	70	1226	100

Note: Confirmed herd breakdowns are herds with visible lesion reactors or herds with no visible lesion reactors but from which *M. bovis* is isolated in the laboratory.

NUMBERS OF BADGERS EXAMINED 1974–1984 (MINISTRY KILLED)

County	1974		1975		1976		1977		1978		1979	
	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*
England (South-West Region)												
Avon	47	7	67	11	60	8	76	12	77	13	122	7
Cornwall	—	—	10	1	85	6	112	17	182	23	151	11
Devon	—	—	—	—	15	0	25	6	45	7	36	3
Dorset	—	—	—	—	—	—	—	—	—	—	3	0
Gloucestershire	78	23	99	23	153	27	199	22	170	13	214	21
Somerset	—	—	—	—	2	0	—	—	—	—	20	0
Wiltshire	16	0	30	3	37	4	20	3	26	0	49	6
Total South-West Region	141	30	206	38	352	45	432	60	500	56	595	48
Bedfordshire	—	—	—	—	—	—	—	—	—	—	—	—
Berkshire	—	—	—	—	—	—	—	—	—	—	—	—
Buckinghamshire	—	—	—	—	—	—	—	—	—	—	—	—
Cambridgeshire	—	—	—	—	—	—	—	—	—	—	—	—
Cheshire	—	—	—	—	—	—	—	—	—	—	—	—
Cleveland	—	—	—	—	—	—	—	—	—	—	—	—
Cumbria	—	—	—	—	—	—	—	—	—	—	—	—
Derbyshire	—	—	—	—	—	—	—	—	—	—	—	—
Durham	—	—	—	—	—	—	—	—	—	—	—	—
East & West Sussex	—	—	—	—	3	0	20	1	36	4	28	2
Essex	—	—	—	—	—	—	—	—	—	—	—	—
Greater Manchester	—	—	—	—	—	—	—	—	—	—	—	—
Greater London	—	—	—	—	—	—	—	—	—	—	—	—
Hampshire	—	—	—	—	—	—	—	—	—	—	—	—
Humberside	—	—	—	—	—	—	—	—	—	—	—	—
Hereford and Worcester	—	—	—	—	—	—	—	—	—	—	—	—
Hertfordshire	—	—	—	—	—	—	—	—	—	—	—	—
Isle of Wight	—	—	—	—	—	—	—	—	—	—	—	—
Kent	—	—	—	—	—	—	—	—	—	—	—	—
Lancashire	—	—	—	—	—	—	—	—	—	—	—	—
Leicestershire	—	—	—	—	—	—	—	—	—	—	—	—
Lincolnshire	—	—	—	—	—	—	—	—	—	—	—	—
Merseyside	—	—	—	—	—	—	—	—	—	—	—	—
Norfolk	—	—	—	—	—	—	—	—	—	—	—	—
Northamptonshire	—	—	—	—	—	—	—	—	—	—	—	—
Northumberland	—	—	—	—	—	—	—	—	—	—	—	—
North Yorkshire	—	—	—	—	—	—	—	—	—	—	—	—
Nottinghamshire	—	—	—	—	—	—	—	—	—	—	—	—
Oxfordshire	—	—	—	—	—	—	—	—	—	—	—	—
Shropshire	—	—	—	—	—	—	—	—	—	—	—	—
South Yorkshire	—	—	—	—	—	—	—	—	—	—	—	—
Staffordshire	—	—	—	—	—	—	—	—	—	—	—	—
Suffolk	—	—	—	—	—	—	—	—	—	—	—	—
Surrey	—	—	—	—	—	—	11	0	20	1	—	—
Tyne & Wear	—	—	—	—	—	—	—	—	—	—	—	—
Warwickshire	—	—	—	—	—	—	—	—	—	—	—	—
West Midlands	—	—	—	—	—	—	—	—	—	—	—	—
West Yorkshire	—	—	—	—	—	—	—	—	—	—	—	—
Total England	141	30	206	38	355	45	463	61	556	61	623	50
Scotland												
Border Region	—	—	—	—	—	—	—	—	—	—	—	—
Inverness	—	—	—	—	—	—	—	—	—	—	—	—
Lothian	—	—	—	—	—	—	—	—	—	—	—	—
Stirlingshire	—	—	—	—	—	—	—	—	—	—	—	—
Strathclyde	—	—	—	—	—	—	—	—	—	—	—	—
West of Scotland	—	—	—	—	—	—	—	—	—	—	—	—
Total Scotland	—	—	—	—	—	—	—	—	—	—	—	—
Wales												
Clwyd	—	—	—	—	—	—	—	—	—	—	—	—
Dyfed	—	—	—	—	—	—	—	—	—	—	—	—
Glamorgan	—	—	—	—	—	—	—	—	—	—	—	—
Gwent	—	—	—	—	—	—	—	—	—	—	—	—
Gwynedd	—	—	—	—	—	—	—	—	—	—	—	—
Powys	—	—	—	—	—	—	—	—	—	—	—	—
Total Wales	—	—	—	—	—	—	—	—	—	—	—	—
Total Great Britain	141	30	206	38	355	45	463	61	556	61	623	50

A TABLE OF BADGERS EXAMINED FOR TUBERCULOSIS (EMPIRICALLY KILLED)

County	1980		1981		1982		1983		1984		TOTAL 1974–1984	
	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*
England (South-West Region)												
Avon	85	12	17	1	111	12	103	12	77	18	842	113
Cornwall	125	13	90	13	153	18	173	21	374	36	1455	159
Devon	39	7	46	2	59	7	212	21	184	27	661	80
Dorset	—	—	1	0	7	0	24	5	109	13	144	18
Gloucestershire	208	15	84	13	271	21	459	72	357	68	2292	318
Somerset	8	1	—	—	17	0	8	0	—	—	55	1
Wiltshire	33	3	46	5	106	7	61	6	51	6	475	43
Total South-West Region	498	51	284	34	724	65	1040	137	1152	168	5924	732
Bedfordshire	—	—	—	—	—	—	—	—	—	—	—	—
Berkshire	—	—	—	—	—	—	—	—	—	—	—	—
Buckinghamshire	—	—	—	—	—	—	—	—	—	—	—	—
Cambridgeshire	—	—	—	—	—	—	—	—	—	—	—	—
Cheshire	—	—	—	—	—	—	—	—	—	—	—	—
Cleveland	—	—	—	—	—	—	—	—	—	—	—	—
Cumbria	—	—	—	—	—	—	14	1	20	0	34	1
Derbyshire	—	—	—	—	—	—	—	—	—	—	—	—
Durham	—	—	—	—	—	—	—	—	—	—	—	—
East & West Sussex	22	2	5	0	14	0	—	—	47	12	175	21
Essex	—	—	—	—	—	—	—	—	—	—	—	—
Greater Manchester	—	—	—	—	—	—	—	—	—	—	—	—
Greater London	—	—	—	—	—	—	—	—	—	—	—	—
Hampshire	—	—	—	—	—	—	—	—	—	—	—	—
Humberside	—	—	—	—	—	—	—	—	—	—	—	—
Hereford and Worcester	—	—	—	—	—	—	—	—	—	—	—	—
Hertfordshire	—	—	—	—	—	—	—	—	—	—	—	—
Isle of Wight	—	—	—	—	—	—	—	—	—	—	—	—
Kent	—	—	—	—	—	—	—	—	—	—	—	—
Lancashire	—	—	—	—	—	—	—	—	—	—	—	—
Leicestershire	—	—	—	—	—	—	—	—	—	—	—	—
Lincolnshire	—	—	—	—	—	—	—	—	—	—	—	—
Merseyside	—	—	—	—	—	—	—	—	—	—	—	—
Norfolk	—	—	—	—	—	—	—	—	—	—	—	—
Northamptonshire	—	—	—	—	—	—	—	—	—	—	—	—
Northumberland	—	—	—	—	—	—	—	—	—	—	—	—
North Yorkshire	—	—	—	—	—	—	—	—	—	—	—	—
Nottinghamshire	—	—	—	—	—	—	—	—	—	—	—	—
Oxfordshire	—	—	—	—	—	—	—	—	—	—	—	—
Shropshire	—	—	—	—	—	—	—	—	—	—	—	—
South Yorkshire	—	—	—	—	—	—	—	—	—	—	—	—
Staffordshire	—	—	—	—	71	13	54	2	25	1	150	16
Suffolk	—	—	—	—	—	—	—	—	—	—	—	—
Surrey	—	—	—	—	—	—	—	—	—	—	31	1
Tyne & Wear	—	—	—	—	—	—	—	—	—	—	—	—
Warwickshire	—	—	—	—	—	—	—	—	—	—	—	—
West Midlands	—	—	—	—	—	—	—	—	—	—	—	—
West Yorkshire	—	—	—	—	—	—	—	—	—	—	—	—
Total England	520	53	289	34	809	78	1108	140	1244	181	6314	771
Scotland												
Border Region	—	—	—	—	—	—	—	—	—	—	—	—
Inverness	—	—	—	—	—	—	—	—	—	—	—	—
Lothian	—	—	—	—	—	—	—	—	—	—	—	—
Stirlingshire	—	—	—	—	—	—	—	—	—	—	—	—
Strathclyde	—	—	—	—	—	—	—	—	—	—	—	—
West of Scotland	—	—	—	—	—	—	—	—	—	—	—	—
Total Scotland	—	—	—	—	—	—	—	—	—	—	—	—
Wales												
Clwyd	—	—	—	—	—	—	8	0	—	—	8	0
Dyfed	50	3	79	5	76	1	79	0	23	1	307	10
Glamorgan	—	—	—	—	—	—	—	—	—	—	—	—
Gwent	—	—	—	—	—	—	—	—	—	—	—	—
Gwynedd	—	—	—	—	—	—	—	—	—	—	—	—
Powys	—	—	—	—	—	—	—	—	—	—	—	—
Total Wales	50	3	79	5	76	1	87	0	23	1	315	10
Total Great Britain	570	56	368	39	885	79	1195	140	1267	182	6629	781

NUMBER OF BADGERS EXAMINED 1972–1984 (OTHER THAN MINISTRY KILLED)

County	1972		1973		1974		1975		1976		1977		1978	
	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*
England (South-West Region)														
Avon	—	—	—	—	16	0	32	3	46	17	31	2	45	2
Cornwall	38	7	223	27	176	24	131	16	59	6	50	4	56	9
Devon	—	—	—	—	—	—	—	—	23	1	31	2	25	3
Dorset	—	—	—	—	1	0	1	0	—	—	—	—	—	—
Gloucestershire	—	—	—	—	78	8	89	11	115	26	137	23	101	10
Somerset	—	—	—	—	1	0	2	0	3	0	1	0	—	—
Wiltshire	—	—	—	—	22	0	13	0	31	2	32	1	25	2
Total South-West Region	38	7	223	27	294	32	268	30	277	52	282	32	252	26
Bedfordshire	—	—	—	—	—	—	—	—	—	—	—	—	3	0
Berkshire	—	—	—	—	—	—	—	—	—	—	4	0	3	0
Buckinghamshire	—	—	—	—	—	—	—	—	1	0	1	0	4	0
Cambridgeshire	—	—	—	—	—	—	—	—	4	0	4	0	8	0
Cheshire	—	—	—	—	—	—	—	—	—	—	9	0	2	0
Cleveland	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cumbria	—	—	—	—	—	—	—	—	1	0	1	0	1	0
Derbyshire	—	—	—	—	—	—	—	—	2	0	7	0	7	0
Durham	—	—	—	—	—	—	—	—	—	—	—	—	—	—
East & West Sussex	—	—	—	—	—	—	—	—	—	—	15	0	12	0
Essex	—	—	—	—	—	—	—	—	1	0	—	—	8	0
Greater Manchester	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Greater London	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hampshire	—	—	—	—	—	—	—	—	6	0	3	0	3	0
Humberside	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Hereford and Worcester	—	—	—	—	—	—	—	—	6	0	5	0	38	1
Hertfordshire	—	—	—	—	—	—	—	—	1	0	1	0	—	—
Isle of Wight	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kent	—	—	—	—	—	—	—	—	9	0	9	0	6	0
Lancashire	—	—	—	—	—	—	—	—	—	—	1	0	1	0
Leicestershire	—	—	—	—	—	—	—	—	8	0	7	0	2	0
Lincolnshire	—	—	—	—	—	—	—	—	3	0	4	0	6	0
Merseyside	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Norfolk	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Northamptonshire	—	—	—	—	—	—	—	—	—	—	3	0	5	0
Northumberland	—	—	—	—	—	—	—	—	—	—	4	0	—	—
North Yorkshire	—	—	—	—	—	—	—	—	2	0	2	0	—	—
Nottinghamshire	—	—	—	—	—	—	—	—	—	—	—	—	2	0
Oxfordshire	—	—	—	—	—	—	—	—	3	0	2	0	4	0
Shropshire	—	—	—	—	—	—	—	—	1	0	2	0	6	0
South Yorkshire	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Staffordshire	—	—	—	—	—	—	—	—	—	—	—	—	9	1
Suffolk	—	—	—	—	—	—	—	—	—	—	—	—	1	0
Surrey	—	—	—	—	—	—	—	—	11	2	2	0	—	—
Tyne & Wear	—	—	—	—	—	—	—	—	1	0	2	0	—	—
Warwickshire	—	—	—	—	—	—	—	—	5	0	8	0	13	0
West Midlands	—	—	—	—	—	—	—	—	1	0	1	0	—	—
West Yorkshire	—	—	—	—	—	—	—	—	—	—	—	—	1	0
Total England	38	7	223	27	294	32	268	30	343	54	379	32	397	28
Scotland														
Border Region	—	—	—	—	—	—	—	—	—	—	—	—	2	0
Inverness	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Lothian	—	—	—	—	—	—	—	—	—	—	—	—	3	0
Stirlingshire	—	—	—	—	—	—	—	—	—	—	1	0	—	—
Strathclyde	—	—	—	—	—	—	—	—	—	—	—	—	—	—
West of Scotland	—	—	—	—	—	—	—	—	1	0	—	—	—	—
Total Scotland	—	—	—	—	—	—	—	—	1	0	1	0	5	0
Wales														
Clwyd	—	—	—	—	—	—	—	—	—	—	1	0	2	0
Dyfed	—	—	—	—	—	—	—	—	4	0	26	0	41	0
Glamorgan	—	—	—	—	—	—	—	—	—	—	—	—	5	0
Gwent	—	—	—	—	—	—	—	—	—	—	5	0	6	0
Gwynedd	—	—	—	—	—	—	—	—	—	—	2	0	1	0
Powys	—	—	—	—	—	—	—	—	—	—	8	0	9	0
Total Wales	—	—	—	—	—	—	—	—	4	0	42	0	64	0
Total Great Britain	38	7	223	27	294	32	268	30	348	54	422	32	466	28

NUMBER OF BADGERS EXAMINED 1972–1984 (OTHER THAN MINISTRY KILLED)

County	1979		1980		1981		1982		1983		1984		TOTAL 1972–1984	
	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*	Number Examined	Number Positive For *M. Bovis*
England (South-West Region)														
Avon	50	3	57	7	100	8	88	7	73	2	64	2	602	53
Cornwall	75	5	102	10	168	18	135	7	186	8	237	4	1636	145
Devon	33	1	36	0	87	3	110	4	132	1	149	3	626	18
Dorset	12	0	—	—	8	0	111	0	124	1	164	0	421	1
Gloucestershire	101	9	144	13	209	30	180	23	171	21	197	15	1522	189
Somerset	20	1	16	0	80	0	148	0	121	1	130	0	522	2
Wiltshire	24	0	56	3	126	10	95	1	86	0	116	2	626	21
Total South-West Region	315	19	411	33	778	69	867	42	893	34	1057	26	5955	429
Bedfordshire	—	—	—	—	1	0	6	0	—	—	5	0	15	0
Berkshire	2	0	—	—	8	0	2	0	5	0	12	0	36	0
Buckinghamshire	2	0	5	0	5	0	29	0	27	0	28	0	102	0
Cambridgeshire	8	0	7	0	12	0	5	0	6	0	6	0	60	0
Cheshire	—	—	1	0	3	0	32	0	38	0	35	0	120	0
Cleveland	—	—	—	—	—	—	—	—	1	0	—	—	1	0
Cumbria	1	0	2	0	4	0	13	1	23	0	18	0	64	1
Derbyshire	7	0	7	0	9	0	17	0	16	0	14	0	86	0
Durham	—	—	3	0	1	0	3	0	3	0	1	0	11	0
East & West Sussex	12	0	9	0	28	0	70	1	95	5	107	6	348	12
Essex	3	0	2	0	6	0	15	0	19	0	38	0	92	0
Greater Manchester	—	—	—	—	—	—	—	—	—	—	1	0	1	0
Greater London	—	—	—	—	—	—	—	—	—	—	1	0	1	0
Hampshire	5	0	10	0	9	0	22	0	39	0	30	0	127	0
Humberside	—	—	—	—	1	0	1	0	—	—	1	0	3	0
Hereford and Worcester	8	0	3	0	12	0	50	0	46	0	68	0	236	1
Hertfordshire	—	—	—	—	3	0	10	0	10	0	11	0	36	0
Isle of Wight	—	—	—	—	1	0	—	—	—	—	2	0	3	0
Kent	4	0	8	0	23	0	30	0	37	0	25	0	151	0
Lancashire	—	—	—	—	—	—	—	—	2	0	2	0	6	0
Leicestershire	5	0	4	0	16	0	36	0	42	0	50	0	170	0
Lincolnshire	4	0	4	0	4	0	5	0	6	0	9	0	45	0
Merseyside	—	—	—	—	—	—	—	—	—	—	1	0	1	0
Norfolk	—	—	—	—	1	0	—	—	—	—	1	0	2	0
Northamptonshire	2	0	9	0	—	—	11	0	25	0	23	0	78	0
Northumberland	1	0	—	—	2	0	9	0	15	0	8	0	39	0
North Yorkshire	1	0	1	0	2	0	4	0	6	0	6	0	24	0
Nottinghamshire	1	0	1	0	2	0	1	0	10	0	4	0	21	0
Oxfordshire	2	0	—	—	20	0	11	0	—	—	9	0	51	0
Shropshire	6	0	2	0	7	0	17	1	17	0	15	0	73	1
South Yorkshire	—	—	—	—	2	0	4	0	—	—	1	0	7	0
Staffordshire	1	0	1	0	2	0	52	1	37	0	31	0	133	2
Suffolk	—	—	—	—	2	0	1	0	6	0	2	0	12	0
Surrey	14	1	14	0	15	0	37	0	34	0	24	0	151	3
Tyne & Wear	1	0	—	—	8	0	4	0	—	—	1	0	17	0
Warwickshire	12	0	7	0	16	0	40	0	41	0	31	0	173	0
West Midlands	—	—	—	—	—	—	—	—	2	0	3	0	7	0
West Yorkshire	—	—	—	—	—	—	—	—	1	0	1	0	3	0
Total England	417	20	511	33	1003	69	1404	46	1502	39	1682	32	8461	449
Scotland														
Border Region	—	—	—	—	—	—	—	—	1	0	—	—	3	0
Inverness	—	—	—	—	—	—	2	0	3	0	—	—	5	0
Lothian	—	—	—	—	—	—	—	—	2	0	1	0	6	0
Stirlingshire	—	—	—	—	—	—	2	0	—	—	—	—	3	0
Strathclyde	—	—	—	—	—	—	—	—	—	—	2	0	2	0
West of Scotland	—	—	—	—	—	—	1	0	—	—	—	—	2	0
Total Scotland	—	—	—	—	—	—	5	0	6	0	3	0	21	0
Wales														
Clwyd	2	0	—	—	5	0	8	0	10	0	6	0	34	0
Dyfed	25	0	19	0	39	0	66	1	77	0	70	1	367	2
Glamorgan	3	0	1	0	4	0	2	0	1	0	2	0	18	0
Gwent	3	0	7	0	11	0	15	0	11	0	13	0	71	0
Gwynedd	1	0	5	0	8	0	23	0	13	0	10	0	63	0
Powys	4	0	7	0	20	0	41	0	56	0	31	0	176	0
Total Wales	38	0	39	0	87	0	155	1	168	0	132	1	729	2
Total Great Britain	455	20	550	33	1090	69	1564	47	1676	39	1817	33	9211	451

APPENDIX 8

WILDLIFE OTHER THAN BADGERS
EXAMINED IN THE VETERINARY LABORATORIES
OF THE AGRICULTURE DEPARTMENTS: 1971 to 1984

Species examined (Faeces shown separately)	Number examined	Number positive for *M. bovis*
	1971 to 1984	1971 to 1984
Bats		
Bat *(Pipistrellus pipistrellus)*	1 (1)	0
Insectivores		
Shrew *(Sorex spp)*	135 (56)	0
Hedgehog *(Erinaceus europaeus)*	22	0
Mole *(Talpa europaea)*	165 (45)	2
Carnivores		
Cat *(Felis catus)*	25	0
Fox *(Vulpes vulpes)*	711 (9)	6
– faeces	42	0
Ferret *(Mustela putorius furo)*	23	0
Polecat *(Mustela putorius)*	8	0
Stoat *(Mustela erminea)*	32 (1)	0
Weasel *(Mustela nivalis)*	33 (13)	0
Mink *(Mustela vison)*	172 (1)	1
Lagomorphs		
Rabbit *(Oryctolagus cuniculus)*	143 (32)	0
Hare *(Lepus capensis)*	14	0
Rodents		
Grey Squirrel *(Sciurus carolinensis)*	177 (21)	0
House Mouse *(Mus musculus)*	58 (58)	0
Woodmouse *(Apodemus sylvaticus)*	744 (401)	0
Yellow Necked Mouse *(Apodemus flavicollis)*	73 (71)	0
Rats *(Rattus norvegicus)*	409 (103)	5
Harvest Mouse *(Micromys minutus)*	3 (3)	0
Voles (Bank and Field) *(Clethrionomys glareolus, Microtus agrestis)*	875 (126)	0
Deer		
Deer *(Cervus elaphus, Capreolus capreolus, Dama dama)*	123	2
– faeces	42	0

Note: The wildlife other than badgers examined in the East Sussex study area are included in the totals examined and shown separately in brackets.

APPENDIX 9

INFECTION RATE IN BADGERS, EXAMINED IN CONNECTION WITH OFFICIAL INVESTIGATIONS (BY PHASE OF THE INVESTIGATIONS), TAKEN FROM JANUARY 1984 TO JUNE 1985 INCLUSIVE

	PRELIMINARY BADGER INVESTIGATION			BADGER REMOVAL OPERATION			MAINTENANCE		
	No. of badgers examined	No. +ve for *M. bovis*	% +ve for *M. bovis*	No. of badgers examined	No. +ve for *M. bovis*	% +ve for *M. bovis*	No. of badgers examined	No. +ve for *M. bovis*	% +ve for *M. bovis*
Avon	17	4	23·5	120	18	15·0	26	6	23·1
Cornwall	131	10	7·6	370	33	8·9	74	6	8·1
Devon	8	1	12·5	161	26	16·1	36	3	8·3
Dorset	50	9	18·0	149	18	12·1	19	2	10·5
Gloucester	36	9	25·0	312	55	17·6	136	31	22·8
Somerset	1	0	0·0	0	0	0·0	0	0	0·0
Wiltshire	34	7	20·6	51	8	15·7	12	0	0·0
Total South West	277	40	14·4	1163	158	13·6	303	48	15·8

Note: The number of badgers examined in this analysis includes all badgers taken in the period and attributed to the official investigations, whether killed by the Ministry or found dead from any other cause during the investigations.

The level of infection and lesions in badgers examined between 1972 and 1984 by county in south west England

County	No. of badgers examined (a)	No. +ve for *M. bovis* (b)	No. +ve for *M. bovis* with lesions (c)	No. of badgers with lesions (d)	% of total badgers, +ve for *M. bovis* (b ÷ a)	% of badgers +ve for *M. bovis* with lesions (c ÷ b)	% of total badgers, +ve for *M. bovis* and with lesions (c ÷ a)	% of total badgers, with lesions (d ÷ a)	% of badgers with lesions, +ve for *M. bovis* (c ÷ d)
Avon	1,447	167	81	87	11·5	48·5	5·6	6·0	93·1
Cornwall	3,088	283	93	140	9·2	32·9	3·0	4·5	66·4
Devon	1,101	87	27	36	7·9	31·0	2·5	3·3	75·0
Dorset	615	19	4	8	3·1	21·1	0·7	1·3	50·0
Gloucester	3,788	499	196	203	13·2	39·3	5·2	5·4	96·6
Somerset	594	3	1	1	0·5	33·3	0·2	0·2	100·0
Wiltshire	1,100	64	22	24	5·8	34·4	2·0	2·2	91·7

Notes: (1) The badgers examined were all those killed by the Ministry and those submitted from other sources for which full records are available; hence some discrepancies with the data at appendices 6 and 7.

(2) +ve for *M. bovis* = organism isolated on cultural examination in the laboratory.

(3) Lesions = gross pathological change which the veterinary officer carrying out the *post mortem* examination suspected was tuberculous.

STATISTICAL ANALYSIS OF HERD BREAKDOWNS 1963–1984

1. A number of groups who gave evidence drew our attention to the trends in the incidence of herd breakdowns, particularly in south west England, as depicted in Appendix 4. Some saw in this graph clear indications of a reduction in outbreaks since gassing commenced in 1975 with signs of an upturn during the moratorium on gassing in new areas which applied during Lord Zuckerman's review, and another upturn after trapping was introduced in 1982. By contrast, others saw evidence of perhaps a general decline in outbreaks over the past 20 years, but rejected any suggestion that the trend showed a convincing fall following the introduction of the badger control strategy. The variability from year to year in the frequency of herd breakdowns, however, prevents any reliable conclusions being drawn from casual perusal of the trend. In these circumstances, formal statistical analysis of the data series offers the only dependable procedure for characterising the pattern of events over time. We undertook such an analysis as an adjunct to the epidemiologist's study which was designed to estimate the impact of control by gassing, reported in Appendix 12.

2. The problem in statistical terms was how best to characterise, compare (and, if possible, explain) the observed pattern in the incidence of herd breakdowns over the period 1963–1984 in the two broad regions of the country distinguished in the data as "south west England" and "the rest of England and Wales". On *a priori* grounds, and from observation of the relevant graphs, three hypotheses suggested themselves. These were: (a) there has been a systematic decline in the annual incidence of herd breakdowns in both regions; (b) a break in both series occurred in the 1975/76 period due (variously) to the imposition of controls on the import of untested cattle from Ireland, the introduction of a more reliable cattle testing procedure using bovine tuberculin, and the commencement of badger control by gassing; and (c) the overall trend in south west England differs from that in the rest of the country. These hypotheses were tested using regression analysis to fit alternative time trend models to each data series.

3. It should be noted that such an approach seeks merely to ascertain which of several alternative postulated explanations (statistical models) seems most consistent with the recorded data. It computes the trend line that best fits the data, but does not explain *why* the trend occurred. To be confident that any explanation advanced for the observed trend is valid, it must be possible to predict solely on the basis of that explanation an expected time path of herd breakdowns which the statistical model would then show to be correct. (Even then, it is possible that two different explanations lead to the same expected pattern of breakdowns; in such circumstances the statistical tests alone are insufficient to discern which explanation is the more likely). For example, in south west England, where annual testing was undertaken in the problem areas, the refinement in the tuberculin test would be expected to have caused a reduction in the measured level of incidence as it took effect over the 12 months following its introduction in 1975 (the improved test was more accurate and so reduced the number of "false positives"). If this hypothesis were true, the statistical test should show a significant "step down" in the time trend at 1975/76. The situation is complicated by the fact that badger control operations commenced at this time also. However, we would expect their success to be reflected, not so much in an immediate drop in the level of breakdowns (since the effect of removing infected badgers should have been to prevent breakdowns that might otherwise have occurred at some later date), but rather in a progressive decline in the rate of incidence in cattle herds subsequent to 1975/76. If this hypothesis were true, the statistical tests should show a significantly greater downward trend after 1975/76 than before. In the rest of the country excluding south west England the refined tuberculin test should have led similarly to a once-and-for-all reduction in the level of incidence—though spread over 2–3 years, since herd testing was on a triennial basis. This effect would have been reinforced by the exclusion of untested cattle imports from Ireland after 1975/76 (such imports were negligible in south west England cattle herds). This leads us again to expect a statistically significant step down in the data series after 1975/76. However, since no badger control operations were conducted in these areas (apart from a few isolated instances in later years) there is no basis for expecting the incidence of breakdowns to show a faster rate of decline post 1976; consequently, we would not expect to find any significant change in the time trend after this date.

4. These are generalised hypotheses thought to be applicable at the broad regional level at which the statistical analysis was conducted. Other plausible but more complex explanations, particularly for the observed time pattern within individual localities in south west England, might be tested if a more detailed analysis could have been undertaken. However, with the information available we could attempt only the more simple trend analysis.

5. In testing these general hypotheses linear, semi-logarithmic and double-logarithmic exponential models were fitted to the data on tuberculosis incidence in cattle herds tested from 1963–84 in south west England and in the rest of England and Wales. Each model contained a time trend variable and proxy ("dummy") variables to capture changes in intercept and in slope, and had the following general form:

$$I = A + bT + cD + dt$$

where I = per cent of reactor herds

A	intercept (indicating level of incidence at start of period)
T	time (measured as the years 1963, 1964, . . . 1984)
D	proxy variable for shift of intercept after 1976
t	proxy variable for change of time trend after 1976
b, c, d	coefficients reflecting the partial impact of the respective explanatory variables on the incidence of reactor herds

The results were considered to be highly satisfactory according to conventional statistical criteria, and those for the best models are summarised in Table A.

Table A: Statistical results for best fitting trend models

	Intercept A	Time trend pre-1975/76 b	Intercept shift 1975/76 c	Time trend shift post-1975/76 d	R^2	DW
South West England (linear model)	1·68 (18·69)**	−0·010 (−0·92)	−0·647 (−2·27)*	0·005 (−0·20)	0·86	1·91
England and Wales excluding South West England (semilog model)	5·36 (9·62)**	−0·071 (−8·80)**	−0·236 (−2·02)*	0·085 (4·83)**	0·92	1·61

Figures in parentheses below coefficients show t statistics.
**significant at the 1% level *significant at the 5% level.

6. In south west England, no consistent downward trend in the incidence of cattle breakdowns since 1963 is discernible. However, there was a significant step reduction in the mean annual incidence from some 1·6% of herds prior to 1975/76 to about 0·9% afterwards. The lack of a statistically significant time trend suggests, therefore, that the reduction in the general level of herd breakdowns over the past 20 years is largely due to this once-and-for-all effect in the mid-1970's. Veterinary opinion suggests that the change in the tuberculin test could not have accounted for a change of this magnitude, which must therefore be due as well to factors not fully understood or included in this analysis. Nor can it be attributed easily to the programme of gassing badgers, the success of which might have been expected to appear in the form of somewhat different statistical results.

7. In the rest of England and Wales the statistically best models showed a significant exponential decline in the incidence of reactor herds at a rate of some 7 per cent per year up to 1975/76, but which ceased after that date. As in south west England, there was a significant step drop in the level of incidence in the mid-1970's period which is consistent with expectations concerning the impacts of Irish cattle restrictions and the improved tuberculin test, but again cannot be explained fully by these factors.

8. Figure A shows the best-fit statistical models superimposed on the actual levels of incidence as charted in Appendix 4. Among other things they raise the following questions:

(a) In south west England, how much of the step drop in incidence that took place in the mid-1970's can be attributed to the gassing programme? We have to remain unsure for three reasons. First, a similar drop occurred also in the rest of the country where gassing did not take place, suggesting that common factors must have been at work in each case. One such factor was possibly the change in the tuberculin test. It is difficult to assert that the onset of gassing in south west England had an exactly equivalent effect on outbreaks as did the restriction of Irish cattle imports in the rest of the country. Second, the gassing programme commenced in mid-1975 and only 33 operations (other than in the research areas of Thornbury and south Dorset) were conducted in the following 12 months; it is most unlikely that this could have had such a significant and immediate effect in reducing breakdowns as was observed. Third, the estimated time trends in incidence (i.e. the lack of any year-on-year decline in incidence post-gassing, and the absence of any discernible change in the trend from the pre- to the post-gassing periods) do not fit the pattern we would expect had the badger control strategy had a significant impact in reducing outbreaks. It is interesting to note that when the number of breakdowns "saved" each year from 1975 to 1983, as estimated in the analysis in Appendix 12, are added to the numbers that actually did occur and the statistical models are re-estimated, the results are not greatly different. A statistically significant step drop (though of slightly less magnitude) still occurs in the mid-1970's, and the trends in incidence before and after this time remain non-signficant. Even allowing for the estimated reductions attributed to the badger control strategy therefore, there remains a significant unexplained drop in incidence in 1975/76.

(b) Does the time path of breakdowns in England and Wales (excluding south west England) reflect some natural "decay rate" of the disease in the cattle population under the present herd testing and culling strategy, with a long term equilibrium having been reached at about 0·08% reactor herds annually? If so, is the apparent equilibrium in south west England—reached earlier and at a significantly higher level—due primarily to continued reinfection from badgers? And if so, can any strategy of badger control, short of total extermination, yield significant reductions in incidence, given that the methods employed to date do not seem to show dramatic success?

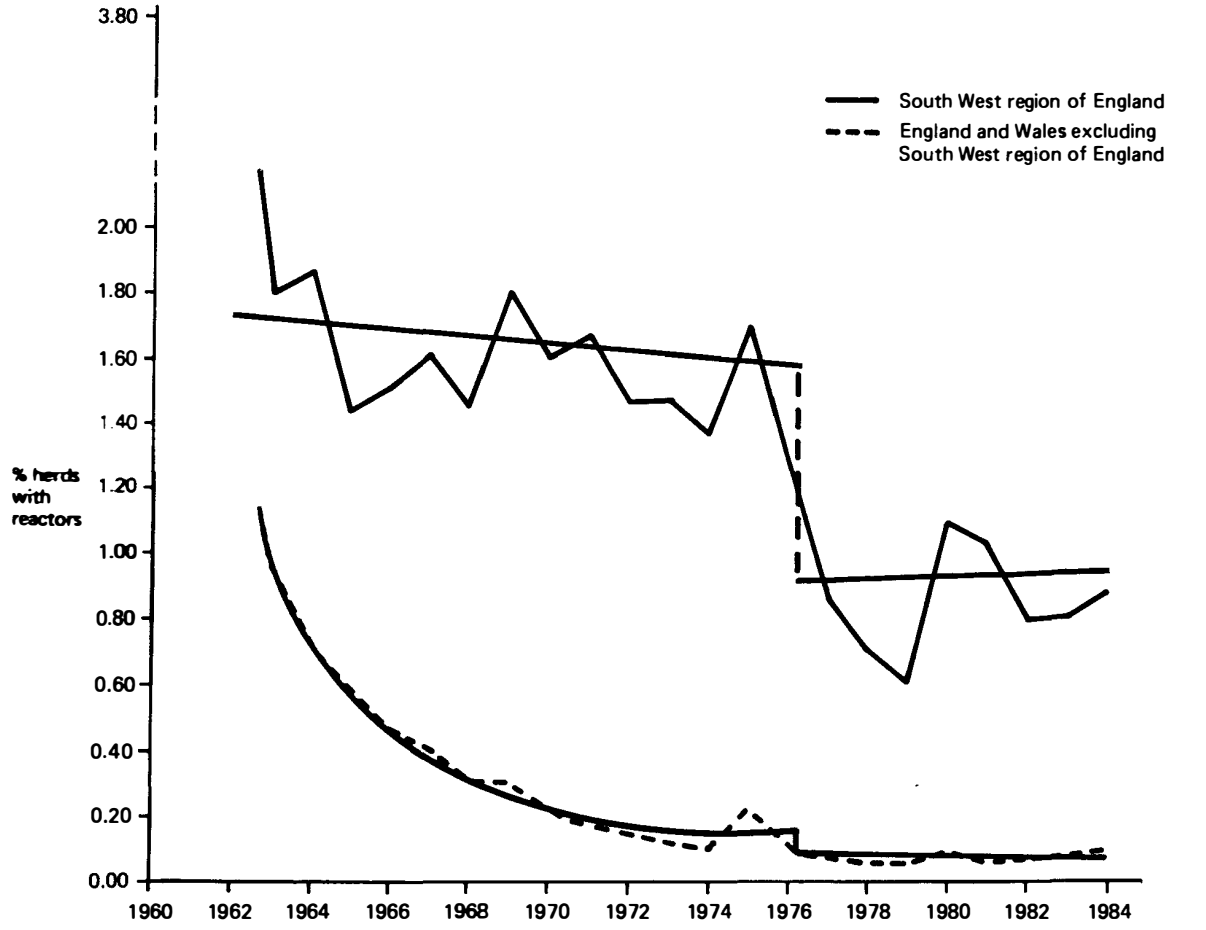
9. These results can claim to be no more than an alternative basis upon which to consider the success of the badger control strategy. Being based on broad regions of the country, they are not strictly comparable with the analysis reported in Appendix 12, which examined the pre-gassing and post-gassing incidences in each individual area that had been subject to gassing. However, both this statistical analysis and that conducted in

Appendix 12 do imply an ability to predict the probable level of herd breakdowns in the absence of a control strategy, based on the extension of historical trends. At one extreme the epidemiologist's analysis predicts total breakdowns would, on average, be higher by some 60–65 per annum (or 40 confirmed breakdowns). The statistical analysis outlined in this appendix might be used to support a prediction at the other extreme—namely, that breakdowns would not be significantly higher if badger control had not occurred, or if it ceased from now on. In the circumstances, no definitive statement concerning the success of the strategy can be made, since the data seem equally consistent with two entirely different hypotheses.

10. Taken together, however, the two analyses might offer acceptable estimates of the upper and lower limits of the strategy's success as measured in terms of the number of breakdowns avoided. It should be noted that these estimates have been developed on the assumption that the (generally level) trend in incidence prior to 1975 would have continued had there been no badger control strategy. Some have disputed this assumption, arguing that badger-related herd breakdowns would have risen progressively (and would do so now were control to cease entirely) as the badger population continues to increase following its protection under legislation. The counter argument states that the incidence of tuberculosis in badgers is declining as the herd testing strategy lowers its incidence in the cattle population. Unfortunately, while both hypotheses are plausible, we have been given no evidence to enable us to decide which is the more likely situation. However, if it were true that the underlying conditions exist for a rising incidence of herd breakdowns in south west England, then the level trend observed since 1975/76 could be explained by the control operations effectively removing infection sources that would in fact have led to herd breakdowns such that no increase in incidence was manifested. In this sense, the strategy would be judged to have had a greater success than that measured in the two analyses, and the quoted 60–65 breakdowns saved would be less than the upper limit of the strategy's estimated effect.

ANNUAL INCIDENCE OF REACTOR HERDS, 1963–1984, AND "BEST-FIT" STATISTICAL TREND LINES
(Indicated trend lines for South West England not significantly different from zero)

Figure A



ANALYSES TO EXAMINE THE EFFECTS OF BADGER CONTROL BY GASSING (1975–1982) ON THE INCIDENCE OF TUBERCULOSIS IN CATTLE HERDS

J W WILESMITH
Central Veterinary Laboratory, Weybridge
(Unpublished)

SUMMARY

Control of badgers by gassing setts, to prevent the transmission of *Mycobacterium bovis* from badgers to cattle, began in August 1975 and continued until June 1982. This method of control was replaced by live cage trapping in August 1982.

Gassing was carried out as a routine in areas in the south-west region of England where there was evidence that cattle had recently become infected by tuberculous badgers. One hundred and sixty-six such areas, with an average size of 7 square kilometres, were gassed.

No areas were deliberately left undisturbed to provide control populations for a formal assessment of the effects of gassing on the incidence of *M. bovis* infection in cattle herds. It was therefore necessary to resort to data recorded during the course of control by gassing and the routine tuberculin testing scheme to make an assessment of these effects. Data obtained from these records allowed an examination of the annual incidence of herds with reactors to the tuberculin test in all gassed areas from the early 1960s to 1983. Variations in the annual incidences of reactor herds were apparent, but there was no evidence of a sustained decline in incidence in the years before gassing. A comparison of the incidence of reactor herds before and after gassing was therefore made. The mean incidence of reactor herds before gassing started was used to estimate expected numbers of reactors post gassing.

The observed number of reactor herds, subsequent to the year of gassing (up to the end of 1983), was 320 less than expected, representing a proportional reduction of 44·4%.

An identical analysis was carried out for the Thornbury experimental area, which was subject to a more rigorous and sustained control effort compared to the routine areas. The observed number of reactor herds post gassing was 61 less than expected, a proportional reduction of 78·9%.

The possibility of a natural decline, unrelated to the effects of gassing, in the incidence of reactor herds, since the introduction of gassing in 1975 was examined using the areas gassed from January 1978 to June 1982. The mean incidences of reactor herds in these areas from 1960 to 1976 were used to determine expected numbers of reactor herds in the time periods from 1977 to the year gassing commenced. An additional 52 reactor herds, compared with the expected, were observed suggesting that the risk of infection for cattle herds in these areas had not declined since 1977.

The annual incidences of reactor herds from 1966 to 1984 in England and Wales were also examined together with the potential effects of the change from Weybridge human purified protein derivative (PPD) to Weybridge bovine PPD in the comparative tuberculin test in March 1975 and the pre-import testing of Irish animals introduced in 1976.

There was no evidence that these changes could have accounted for the decline in incidence observed in the gassed areas. Analyses of the available data therefore suggested that the control of badgers in areas in the south-west region from 1975 to 1982 reduced the risk of infection for cattle herds in these areas.

SUBMISSIONS OF EVIDENCE

a. Organisations which submitted written evidence:—

Agricultural and Allied Workers National Trade Group
Badger, incorporating Badger Concern
Badger Protection Society, Croydon
British Veterinary Association
British Veterinary Zoological Society
Brock Badger Group
Clwyd Badger Group
Cornwall Trust for Nature Conservation
Cotswold Wildlife Preservation Society
Country Landowners' Association
Dartmoor Badgers Protection League
Farmers' Union of Wales
Friends of the Earth
Gwent Badger Group
Institute of Terrestrial Ecology
Ministry of Agriculture, Fisheries and Food
National Farmers' Union (HQ Animal Health Committee and Concern for Animals Group, and County Branches for Gloucestershire/N Avon/Wiltshire, Pembrokeshire and Somerset/S Avon)
Nature Conservancy Council
Royal Society for Nature Conservation
Scottish Wildlife Trust
Somerset Trust for Nature Conservation
Staffordshire Nature Conservation Trust
Universities Federation for Animal Welfare
Welsh Office Agriculture Department
Wildlife Link Badger Working Group (whose members include representatives of the Fauna and Flora Preservation Society, the Mammal Society, the People's Trust for Endangered Species, the Royal Society for Nature Conservation, the Royal Society for the Prevention of Cruelty to Animals, the Wiltshire Trust for Nature Conservation and World Wildlife Fund—UK)
Wiltshire Trust for Nature Conservation

b. In addition written evidence was received from 39 individuals including some of the liaison officers appointed by the County Naturalists' Trusts in response to recommendation (x) of Lord Zuckerman's report.

c. Oral evidence was provided by—

(i) Organisations
Brock Badger Group
Consultative Panel on Badgers and Tuberculosis (whose members include representatives of the Agricultural and Allied Workers National Trade Group, the British Veterinary Association, the Country Landowners' Association, the Fauna and Flora Preservation Society, the Mammal Society, the National Farmers' Union, the Nature Conservancy Council, the Royal Society for Nature Conservation, the Royal Society for the Prevention of Cruelty to Animals and the Universities Federation for Animal Welfare)
Dartmoor Badgers Protection League
Ministry of Agriculture, Fisheries and Food
National Farmers' Union (representatives from Cornwall, Devon and Gloucestershire)
Nature Conservation Trusts (representatives from Cornwall, Devon, Goucestershire, Somerset, Staffordshire and Wiltshire)
Welsh Office Agriculture Department
Wildlife Link Badger Working Group

(ii) Individuals
Professor R M Anderson (Imperial College of Science and Technology, London)
Dr P Benham (University of Reading)
Dr P Chanin (University of Exeter)
Dr H Kruuk (Institute of Terrestrial Ecology, Banchory)
Dr J L Stanford (Middlesex Hospital Medical School, London)

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