A HISTORY OF BOVINE TB *c.*1965–*c.*2000

The transcript of a Witness Seminar held by the History of Modern Biomedicine Research Group, Queen Mary University of London, on 13 May 2014

Edited by C Overy and E M Tansey

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WHAT IS A WITNESS SEMINAR?

The Witness Seminar is a specialized form of oral history, where several individuals associated with a particular set of circumstances or events are invited to meet together to discuss, debate, and agree or disagree about their memories. The meeting is recorded, transcribed, and edited for publication.

This format was first devised and used by the Wellcome Trust's History of Twentieth Century Medicine Group in 1993 to address issues associated with the discovery of monoclonal antibodies. We developed this approach after holding a conventional seminar, given by a medical historian, on the discovery of interferon. Many members of the invited audience were scientists or others involved in that work, and the detailed and revealing discussion session afterwards alerted us to the importance of recording 'communal' eyewitness testimonies. We learned that the Institute for Contemporary British History held meetings to examine modern political, diplomatic, and economic history, which they called Witness Seminars, and this seemed a suitable title for us to use also.

The unexpected success of our first Witness Seminar, as assessed by the willingness of the participants to attend, speak frankly, agree and disagree, and also by many requests for its transcript, encouraged us to develop the Witness Seminar model into a full programme, and since then more than 60 meetings have been held and published on a wide array of biomedical topics.[1] These seminars have proved an ideal way to bring together clinicians, scientists, and others interested in contemporary medical history to share their memories. We are not seeking a consensus, but are providing the opportunity to hear an array of voices, many little known, of individuals who were 'there at the time' and thus able to question, ratify, or disagree with others' accounts – a form of open peer-review. The material records of the meeting also create archival sources for present and future use.

The History of Twentieth Century Medicine Group became a part of the Wellcome Trust's Centre for the History of Medicine at UCL in October 2000 and remained so until September 2010. It has been part of the School of History, Queen Mary University of London, since October 2010, as the History of Modern Biomedicine Research Group, which the Wellcome Trust

[1] See pages 121–6 for a full list of Witness Seminars held, details of the published volumes, and other related publications.

funds principally under a Strategic Award entitled 'The Makers of Modern Biomedicine'. The Witness Seminar format continues to be a major part of that programme, although now the subjects are largely focused on areas of strategic importance to the Wellcome Trust, including the neurosciences, clinical genetics, and medical technology.[2]

Once an appropriate topic has been agreed, usually after discussion with a specialist adviser, suitable participants are identified and invited. As the organization of the seminar progresses and the participants' list is compiled, a flexible outline plan for the meeting is devised, with assistance from the meeting's designated chairman/moderator. Each participant is sent an attendance list and a copy of this programme before the meeting. Seminars last for about four hours; occasionally full-day meetings have been held. After each meeting the raw transcript is sent to every participant, each of whom is asked to check his or her own contribution and to provide brief biographical details for an appendix. The editors incorporate participants' minor corrections and turn the transcript into readable text, with footnotes, appendices, a glossary, and a bibliography. Extensive research and liaison with the participants is conducted to produce the final script, which is then sent to every contributor for approval and to assign copyright to the Wellcome Trust. Copies of the original, and edited, transcripts and additional correspondence generated by the editorial process are all deposited with the records of each meeting in the Wellcome Library, London (archival reference GC/253) and are available for study.

For all our volumes, we hope that, even if the precise details of the more technical sections are not clear to the non-specialist, the sense and significance of the events will be understandable to all readers. Our aim is that the volumes inform those with a general interest in the history of modern medicine and medical science; provide historians with new insights, fresh material for study, and further themes for research; and emphasize to the participants that their own working lives are of proper and necessary concern to historians.

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[2] See our Group's website at www.histmodbiomed.org

ACKNOWLEDGEMENTS

The subject of a history of bovine TB was suggested by Dr Angela Cassidy, who is a Wellcome Trust Research Fellow at King's College London, where she is working on a history of bovine TB in the UK between 1965 and 1995. We are very grateful to her for her help in the planning of this meeting and for providing material used in the editorial process. We thank Professor Wyn Grant for chairing the occasion and Professor Keir Waddington for his excellent introduction. Our gratitude also goes to Mr Michael Clark, Dr Gordon McGlone, and Mr John Montague for providing images to illustrate the volume, and the Wellcome Library, London, for permission to use photographs taken at the meeting; material is also reproduced under the Open Government Licence.

As with all our meetings, we depend a great deal on Wellcome Trust staff to ensure their smooth running: the Audiovisual Department, Catering, Reception, Security, and Wellcome Images. We are also grateful to Mr Akio Morishima for the design and production of this volume; the indexer Ms Liza Furnival; Mrs Sarah Beanland and Ms Fiona Plowman for proofreading; Mrs Debra Gee for transcribing the seminar; Ms Emma Jones for assisting with running the seminar and Mr Adam Wilkinson who assisted in the organization and running of the meeting. Finally, we thank the Wellcome Trust for supporting this programme.

Tilli Tansey

Caroline Overy

School of History, Queen Mary University of London

ILLUSTRATIONS AND CREDITS*

* Unless otherwise stated, all photographs were taken by Thomas Farnetti, Wellcome Trust, and reproduced courtesy of the Wellcome Library, London.

ABBREVIATIONS AND GLOSSARY[1]

AHVLA	Animal Health and Veterinary Laboratories Agency, an executive agency of Defra
BCG	Bacillus Calmette–Guérin, which is used to manufacture tuberculosis vaccines
Biosecurity	security from transmission of infectious diseases
Bovine tuberculosis	an infectious disease in cattle caused by *Mycobacterium bovis (M. bovis)*
Breakdown	detection of exposure to *M. bovis* infection in a herd (e.g. detection of a bTB reactor or signs of possible bTB at post mortem).
BSE	Bovine spongiform encephalopathy
bTB	bovine tuberculosis
CJD	Creutzfeldt–Jakob disease
CVL	Central Veterinary Laboratories
CVO	Chief Veterinary Officer
Defra	Department for Environment, Food and Rural Affairs
DIVA	a test to Differentiate Infected from Vaccinated Animals
FMD	foot and mouth disease
FoI	Freedom of Information
Herd prevalence	depicts the proportion of herds that are affected by a disease/condition in a defined area

[1] Part taken from Defra (2014) *The Strategy for achieving Officially Bovine Tuberculosis Free status for England*, April 2014, London: Defra, pages 72–6, available online at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/300447/pb14088-bovine-tb-strategy-140328.pdf (accessed 6 May 2014). Contains public sector information licensed under the Open Government Licence v3.0. www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ (accessed 17 June 2015).

High risk area for bTB	an area defined geographically in which cattle herds have a greater likelihood of experiencing a bTB breakdown. It includes geographical areas in which there is a relatively high herd prevalence of bTB
Incidence	reflects the number of cases of infection or disease
ISG	Independent Scientific Group, which supervised the Randomised Badger Culling Trial
Low risk area for bTB	An area defined geographically in which cattle herds have a lower likelihood of experiencing a bTB breakdown. It includes geographic areas with very low herd prevalence of bTB and where the disease is not believed to be maintained by badgers and is primarily caused by cattle movements
MAF	Ministry of Agriculture and Fisheries (MAFF from 1955)
MAFF	Ministry of Agriculture, Fisheries and Food, replaced by Defra in 2001
Mycobacteria	a family of bacteria which includes *Mycobacterium bovis*
***Mycobacterium bovis* (*M. bovis*)**	the bacterium which causes bovine tuberculosis
***Mycobacterium tuberculosis* (*M. tuberculosis*)**	one of the bacteria which causes tuberculosis in humans
NAO	The North Atlantic Oscillation
NFU	National Farmers Union
OTF	Officially Bovine Tuberculosis Free, as defined in Council Directive 64/432/EEC. OTF status may apply to herds, regions or member states

Perturbation	disruption of badger social groups causes badgers to range more widely than they would normally and come into contact more often with other animals (including both cattle and other badgers)
Post-movement test	a tuberculin skin test applied to an animal after it has moved between premises
PPD	Purified protein derivative
Pre-movement test	a tuberculin skin test applied to an animal before it has moved between premises
Prevalence	see Herd prevalence
R&D	research and development
RBCT	Randomised Badger Culling Trial, a scientific study carried out from 1998 to 2005 to quantify the impact of culling badgers on TB incidence in cattle
Reactor	an animal which gives a positive reaction to the tuberculin skin test as defined in Council Directive 64/432/EEC
Reservoir host	animals which can routinely harbour *M. bovis* infection
Routine herd testing	the programme of routine surveillance testing of breeding cattle in herds, using the tuberculin skin test in line with Council Directive 64/432/EEC
RTA	road traffic accident
Surveillance	an effort to detect disease in a population by using diagnostic or clinical methods. For bTB in England, formal surveillance is carried out with frequent whole or routine herd testing, by pre-movement testing of all cattle over 42 days of age leaving premises in the high risk area and by inspecting all cattle carcasses
Test interval	the period of time between tuberculin skin tests

Tuberculin	mycobacterial proteins used in tests to detect bovine tuberculosis
Tuberculin skin test	measuring an animal's reaction to injections of tuberculin carried out in line with Council Directive 64/432/EEC. The single intradermal cervical test involves a single injection of bovine tuberculin in the neck; the single intradermal cervical comparative test involves single injections of bovine and avian tuberculin in the neck
vCJD	variant Creutzfeldt–Jakob disease
VI	veterinary investigation

INTRODUCTION

How do we solve the problem of bovine tuberculosis? For over a hundred years this has proved a contentious and intractable question. The complexities that have surrounded the transmission of bovine tuberculosis (bTB) and attempts to protect consumers and eradicate the disease in cattle not only reveal conflicting constructions of risk and expertise, but also highlight how the boundaries between animals and humans, and between different animals, can be disrupted. Whereas in her opening comments Angela Cassidy sensitively identifies the broad historical shifts that structured controversy between the late 1960s and the mid-1990s, in this introduction, I outline the history of responses to bTB from the 1890s to *c.*2000 to place the volume in context, and highlight some of the historical parallels between contemporary and earlier debates.

For Victorian health officials and governments bTB was essentially a public health problem tackled through inspection to protect consumers from ingesting meat and milk from tuberculous livestock. While local public health and veterinary controls remained problematic, by 1911 the findings of three royal commissions had reinforced pre-existing assumptions about the dangers of bTB to consumers and the importance of cattle-to-human and cattle-to-cattle transmission. As attention shifted after 1900 from diseased meat to infected milk, European models of eradication attracted interest as concern about bTB drew on anxieties about food safety, child health, national efficiency, and farming. For the public health lobby, the eradication of bTB offered a means to reduce an important childhood disease, while for farmers and the Ministry of Agriculture and Fisheries (MAF) there were important economic considerations. In the 1920s, efforts were made to increase resistance among cattle through breeding and improved stable hygiene, and research was conducted into developing a cattle vaccine. With the science and value of pasteurization initially contested, measures to promote disease-free herds and support for eradication schemes gained ground in the 1920s and 1930s with the 1937 Agriculture Act establishing the rudiments of a national system of testing in cattle with veterinarians at the centre. However, the voluntary nature and economics of eradication and a shift from arable to livestock and dairy farming, combined with farmers' apparent unwillingness to stamp out bTB, ensured that levels of the disease in the national herd remained high until the 1950s.[1]

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[1] Phillips and French (1999).

Progress in eradicating bTB was therefore slow: it was not until 1964 that it became government policy to detect and contain the disease in cattle through routine testing, slaughter, compensation, and movement controls. By 1971, complete eradication had not been achieved but the incidence of reactors in individual herds had fallen dramatically. It was in this context that the discovery in 1971 of bTB in a dead badger at a farm in Gloucester following an atypical outbreak of bTB provoked immediate concern. While as the contributors to this volume reveal, the reasons for rising levels of bTB in the UK after 1971 remain open to speculation, veterinarians and farmers highlighted a 'reservoir' of infection in wild badger populations and in 1975 a programme of badger culling was started. Despite the absence of research demonstrating a concrete link, MAFF (formerly MAF) became embroiled in a campaign to stop badger-transmitted TB in cattle. Badger-borne TB became an intractable problem and culling a deeply contentious issue. As attention focused on badgers, the role of cattle movements, other animals, or testing in the spread of the disease attracted little attention despite questions having been asked about these vectors since the 1890s. Only by the mid-2000s did work confirm much earlier assumptions that cattle-to-cattle transmission was an important factor, while studies came to show that culling and perturbation increased incidences of TB in badgers, issues explored by the contributors as they unravel competing opinions and uncertainties about rising levels of bTB in the UK.

Whereas before the 1960s appeals for the eradication of bTB were made in the name of public health, child health and national efficiency, or to support the growing dairy industry, the post-1965 history of bTB as a public scientific and policy controversy has been a complex one of competing interpretations, interests groups, and emotions. As MAFF commented in 1986, since the 1970s, badger controls have been influenced by 'practical and political expediency, field experience, research, public relations considerations, the perplexities and imponderable nature of TB badger/cattle relationships and much discussion among interested parties'.[2] They have equally been shaped by a particular perception of the badger as a problem, and by appeals based on different constructions of 'good' and 'bad' badgers.[3]

As emotively charged images of badgers and culling were presented in the media and by campaigners against culling, policymakers increasingly sought to involve a wider range of interest groups. For some the involvement of conservation and

[2] Cited in Grant (2009), page 561.

[3] Cassidy (2012).

animal welfare groups resulted in a paralysis of policy, but responses to bTB need to be seen in the context of the uncertainties surrounding transmission. With evidence of the role of badgers in the resurgence of bTB remaining circumstantial, proving that badgers were responsible for outbreaks was problematic. In an effort to resolve uncertainties, successive governments turned to expert advisory committees as they attempted to navigate the emotive and politicized issues surrounding culling. If the Badger Panel established in 1976 to provide a forum for advice from experts and leading organizations explained government policies and sought agreement from interest groups, further reports were commissioned to provide an elusive evidence-base for policy. Whereas the 1980 Zuckerman report reinforced the need for culling and supported a clean ring strategy, the 1986 Dunnet report tried to reconcile competing interests and recommended a scaling down of culling, an approach that remained in place for ten years as BSE came to dominate anxieties about animal health and food safety. In 1996, the Badger Panel ceased to meet following the creation of an independent review to investigate whether badgers were responsible for the spread of bTB in cattle and whether culling strategies worked. Two years later, the Independent Scientific Group on Cattle TB was set up to conduct the Randomised Badger Culling Trial to once again address uncertainties and establish the effects of badger culling on incidences of bTB in herds. Its findings were contradictory. In response the then Department of Environment, Food and Rural Affairs secretary, Hilary Benn, decided that a renewed cull would be too risky in the face of uncertainty and public opposition. It is against this policy background, uncertainties surrounding transmission, and the emotions generated by culling, that contributions to this Witness Seminar need to be understood as they fill a vital gap in historical studies by addressing policy responses to bTB after 1960.

While badger culling introduced a hitherto unknown emotional dimension to debates about bTB and involved the public and NGOs in animal health policies in new ways, the pre- and post-1965 history of bTB suggests interesting recurrent themes around bTB and animal diseases. Responses to bTB not only reveal important issues about the role of scientific knowledge in policy and the boundaries of expertise in responses to epizootic and zoonotic diseases, but also their limits in the face of questions about risk and the complexities of how bTB is transmitted to humans or between animals. Whether framed as a public health, laboratory, veterinary, or farming problem, since the 1890s uncertainty and the pursuit of evidence to support policy has been central to responses to bTB. Questions about diagnosis, testing, and vaccination, important

in contemporary debates, equally troubled meat inspectors, veterinarians, laboratory scientists, and farmers from the 1900s to the 1940s. Likewise, since the 1890s, rather than science setting the agenda, uncertainties surrounding bTB have repeatedly been met through government investigations and state-sponsored studies into the nature of transmission and testing in an attempt to find answers. Tensions between different models of expertise and shifting expert groups have continually resurfaced in responses to bTB. For example, from the 1870s to the 1930s conflict between public health officials and veterinarians over who was best qualified to protect the public and identify tuberculous cattle was an important feature of debate. Further issues have regularly reappeared around bTB. Here we might think of repeated debates about the impact of bTB on farming and the cost of eradication or the obstacles to testing, which were just as important in the 1920s and 1930s as they are to contemporary policymakers. Thinking about this longer history of bTB not only allows us to place this volume in context, but also helps identify recurrent concerns that are important to understanding the post-1965 history of responses to bTB, eradication, and the problems of policymaking in the face of epizootic and zoonotic diseases.

Professor Keir Waddington
Cardiff University

Figure A

A HISTORY OF BOVINE TB *c.*1965–*c.*2000

The transcript of a Witness Seminar held by the History of Modern Biomedicine Research Group, Queen Mary University of London, on 13 May 2014

Edited by C Overy and E M Tansey

A HISTORY OF BOVINE TB *c.*1965–*c.*2000

Participants*

Dr Angela Cassidy
Mr Michael Clark
Dr Gareth Davies (first half only)
Professor Wyn Grant (Chair)
Ms Emma Jones
Professor David Macdonald
Dr Gordon McGlone
Mr Keith Meldrum
Dr Richard Meyer
Mr John Montague
Ms Fiona Stuart
Mr Mark Thomasin-Foster
Mr Adam Wilkinson
Mr David Williams

Apologies include: Dr Andy Biggs, Mr Colin Booty, Dr Chris Cheeseman, Dr Murray Corke, Dr Paul Duff, Dr John Gallagher, Professor Charles Godfray, Lord Krebs, Mr Robert Lowson, Lord May, Professor John McInerney, Mr Tim Radford, Mr Tim Sands, Professor Tilli Tansey

Figure 1: Participants at the Witness Seminar

* Biographical notes on the participants are located at the end of the volume

Ms Emma Jones: Hello, a very warm welcome to you all from the History of Modern Biomedicine Research Group. I'm Emma Jones, Research Assistant to Professor Tilli Tansey and an editor of the Witness Seminar publications, one of which we very much hope to be producing from today's proceedings. Professor Tansey, who is head of our group, cannot be with us today as she is in Russia contributing to the celebrations of the 200th Anniversary of the Kazan State Medical University. Dr Angela Cassidy, whom I'm sure many of you already know, suggested this meeting to us last year, and Professor Tansey felt it was a highly appropriate subject for one of our Witness Seminar meetings. Within our current Strategic Award from the Wellcome Trust – Makers of Modern Biomedicine – it falls into two categories, global health and infectious diseases and the ethics of biomedical practice and research. We also have a link historically from one of our Witness Seminars in 2001 on the foot and mouth disease outbreak of 1967 and the aftermath of that.[1] So it's been quite a long time since we've done a Witness Seminar on any animal health and welfare issues, and we're delighted to be broaching such a topic again. Angela particularly noted in her proposal to us that there was a dearth of historical information about the topic from the 1950s onwards, so we see this as an important occasion to plug that gap and that's really your job, and we're delighted you're all here today. We hope you will feel free to speak openly and candidly about your experiences and the history to which you are authentic witnesses. There is an outline programme (Table 1), but please don't feel you have to stick too rigidly to this – it is a guideline. We find in these meetings that memories trigger other memories. You know what happened at the time, but what didn't happen is sometimes just as interesting. Who were the key people, both present in this room and maybe not present? How did policy, activism, and science surrounding bovine TB emerge at this period? What were the driving forces in the bovine TB debate and the twists and turns that it took? What happened behind the scenes of the published newspaper stories and the published scientific papers? We note that this is very much *a* rather than *the* history of the subject; there are a lot of people in the apologies list who can't be with us today, for example. Nothing that you say will be published without your permission and you will be asked to assign copyright to the Wellcome Trust.

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[1] Reynolds and Tansey (eds) (2003).

Brief historical introduction
Mid-1960s and 1970s:
• First links between bovine TB infection in badgers and cattle
• Campaigning for badger protection
• Establishment of 'badger control policies'
Early 1980s:
• Zuckerman report (1980) *Badgers, Cattle and Tuberculosis*
Mid-1980s:
• Dunnet report (1986) *Badgers and Bovine Tuberculosis* – review of policy
Late 1980s and 1990s:
• Badger Panel
• Krebs report (1997) *Bovine Tuberculosis in Cattle and Badgers*

Table 1: Outline programme for 'A History of Bovine TB *c.*1965–*c.*2000' Witness Seminar

A key part of Angela's expertise and knowledge in advising us on setting up today's meeting was suggesting an appropriate Chair, and we are very pleased that Professor Wyn Grant has agreed to take this task on. I'm sure he needs no introduction to this group; he is a distinguished expert in animal health and welfare issues and was formerly Deputy Principal Investigator of the Rural Economy and Land Use Programme's Governance of Livestock Disease Project at Warwick University from 2007 to 2010, in which, of course, bovine TB featured as a topic. I'm delighted to hand over today's proceedings to Professor Grant.

Professor Wyn Grant: Thank you. Well, I don't need to say very much. I guess my qualification to be here today is that I would like to think that I've read most of the papers in the National Archives in Kew, and indeed at the National Archives in Edinburgh, relating to bovine tuberculosis and indeed to other diseases of cattle, but I'm sure there are a few things that escape my attention. But now I'm going to hand over to Angela, who is going to give us a brief, historical introduction.

Dr Angela Cassidy: Thank you, Wyn. I'm really pleased you were all able to come today. I first got interested in bovine TB (bTB) about five years ago. One of my specialist research topics is public scientific controversies,

Figure 2: Professor Wyn Grant

and so I started looking at the current bTB controversy, and one of the key findings of that work was that we needed to go back and look at the past in order to understand the present controversy; and also that, as I'm sure many of you are very well aware, the events of the past are constantly being cited and used in arguments about bovine TB and badgers today. In the early stages of planning the fellowship research that I'm now doing, funded by the Wellcome Trust, I started looking at what the historical literature has to say about this topic and, as has already been mentioned, I discovered quite rapidly that the existing historical literature on bovine TB actually stops around the 1950s. There's a great deal of work on the nineteenth century and the early twentieth century – how the link between cattle and human TB was gradually established and how systems of regulations were put into place, things like milk pasteurization.[2] But then you look at the historical literature and it does pretty much stop, aside from Wyn's own research that was published a few years ago.[3] Then we also have a contemporary social science literature that's looking at the current situation[4] and we have this very large gap in the middle.

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[2] For a history of bovine TB and public health between 1860 and 1914, see Waddington (2006); also Jones (2004) and Waddington (2004). For the period up to 1950, see Atkins (2000); Atkins (n.d.).

[3] Grant (2009); Carslake *et al.* (2011).

[4] See for example, Cassidy (2012); Enticott (2001, 2015); Maye *et al.* (2014); Lodge and Matus (2014); Wilkinson (2007).

Figure 3: Dr Angela Cassidy

It is essentially my job to start trying to fill that gap, so I'm really pleased that you can be here so we can start this process of actually understanding what happened between the late 1960s and the present day, leading to the situation we're in now. There have been several quite interesting historical shifts that have happened between the late 1960s and the mid-1990s when we moved into the current phase of the controversy. Firstly, there's very much a shift where, around the middle of the twentieth century, the bovine TB issue was largely seen as driven by public health concerns – an animal health topic but driven very much by concerns about TB in humans. The controversy today, particularly the public controversy, tends to be framed in terms of animal health versus wildlife health. Human health does not enter into the current controversy very much. So we have a really interesting shift that has happened there in terms of how this disease is framed – whether it's about humans, domestic animals, or wildlife. Secondly, the connection was made between badgers and TB during this time and so we have two different policy spheres coming together, and that's a very interesting situation to look at if you're an historian. Thirdly, we have changes in terms of British farming and changes in how British people relate to animals, both wild animals and farmed animals, and how we talk about animal welfare. So that again is a really interesting shift

Figure 4: Ms Emma Jones and Dr Gareth Davies

that has happened during this time. Finally, there are also big changes that have happened in terms of the relationships between experts and different kinds of experts, policy makers, and politicians. Again, that's another issue, which I think will be very interesting to hear about today. So at that point I'm going to stop to hand back over to Wyn.

Grant: We don't have to stick too rigidly to the outline but it is a guide for us, to start back in the late 1960s, early 1970s. Of course, some of you may not have been involved then but at least you'd have memories of the people who preceded you who were responsible for policy in this area. So that would also be of interest.

Dr Gareth Davies: I'd like to start by asking: Why do we need to control tuberculosis in cattle? Leaving aside the political implications and European rules, the routes of infection into the human population are effectively blocked through pasteurization of milk and by meat inspection procedures. So I think we do need to ask: Why are we spending all this money on controlling a disease, which in fact isn't necessarily a major threat to the human population?[5]

[5] See comments by Mr Michael Clark on page 16 and Mr Keith Meldrum on page 30.

Figure 5: Mr John Montague and Mr David Williams

Mr John Montague: Not a specific response but just to make the point that, although you said that all routes of transmission from cattle are blocked, with the change in the BCG vaccination policy in the human population[6] and the increase in TB in a whole range of species now, you may well be having certain parts of the population exposed to risk just as we've had humans infected from cats in the Newbury area in the last 12 months.[7]

Grant: Perhaps if we could return to the past and the situation when, of course, bovine tuberculosis was again identified in badgers, in Gloucestershire as I recall. I don't know if anyone would like to address what happened then?

Mr Keith Meldrum: I was involved in the field as a veterinary officer in the Ministry of Agriculture, Fisheries and Food (MAFF) working on tuberculosis eradication. In the early 1970s I came into Tolworth, into Head Office, and I was involved with an inquiry into bovine tuberculosis. It was an interesting

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[6] In 2005 the BCG immunization policy was changed from a universal school vaccination programme given at age 10–15, to a targeted immunization programme given to children at high risk of exposure.

[7] The first documented case of cat-to-human transmission of *M. bovis* occurred in the Newbury area where, between December 2012 and March 2013, nine cats were found to be infected with *M. bovis* (Roberts *et al.* (2014)). In March 2014, it was widely reported that two people who had had contact with the infected cats were also found to have a TB infection.

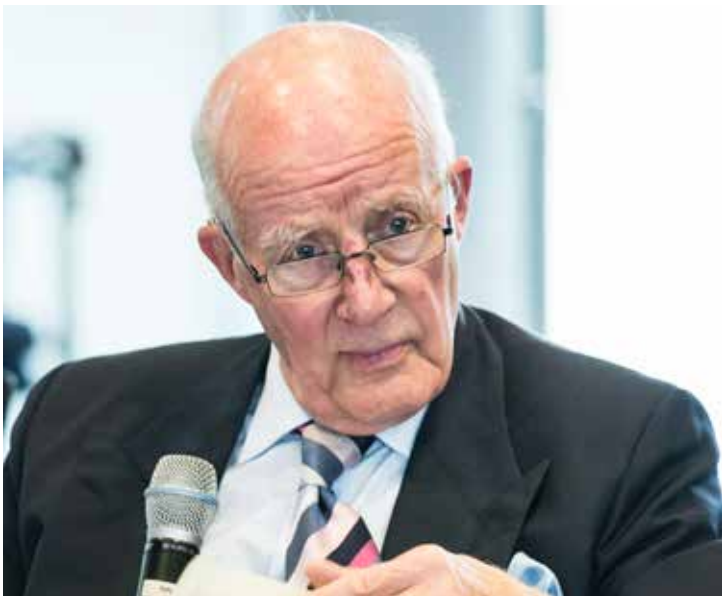

Figure 6: Mr Keith Meldrum

report.[8] The team consisted of Alun Richards, who was Assistant Chief Veterinary Officer, Bill Watson, who later on became director of the Central Vet Lab, myself, and Eddie Boughton, a bacteriologist from the Central Vet Lab.[9] This is, to me, an interesting report because it was looking at the problems of tuberculosis in West Penwith in Cornwall, and some of the recommendations are interesting, but in particular, comment being made on badgers – Fiona can add to this, I'm sure. The report makes it quite clear that at that time, in 1972 therefore, it was known that badgers could be, and were, affected with tuberculosis. There is an interesting postscript dated 27 June 1972 in that report, which says that 'subsequent to the completion of the report tubercle bacilli were isolated from badger faeces in West Penwith'.[10] That was following the work done by Roger Muirhead in Gloucestershire when he picked up the first badgers that were identified to have tuberculosis.[11] I found that report interesting; certainly as far as I was concerned, it opened the door to extension of our knowledge about tuberculosis and the particular

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[8] MAFF (1972).

[9] The Central Veterinary Laboratories were part of MAFF.

[10] MAFF (1972), point 4:30.

[11] Bovine TB was first identified in badgers in Gloucestershire in 1971 (Muirhead (1972)); see also note 19.

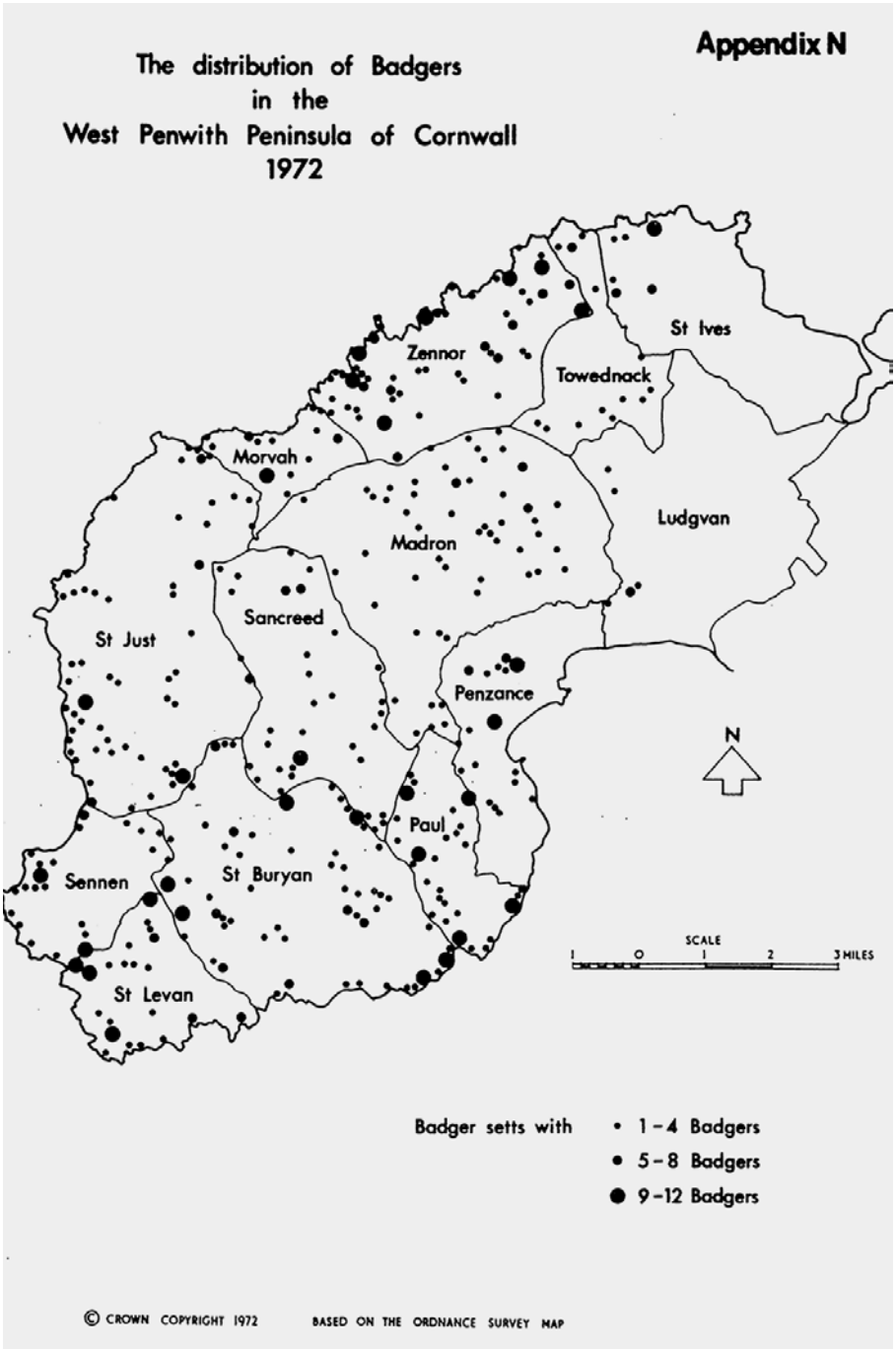
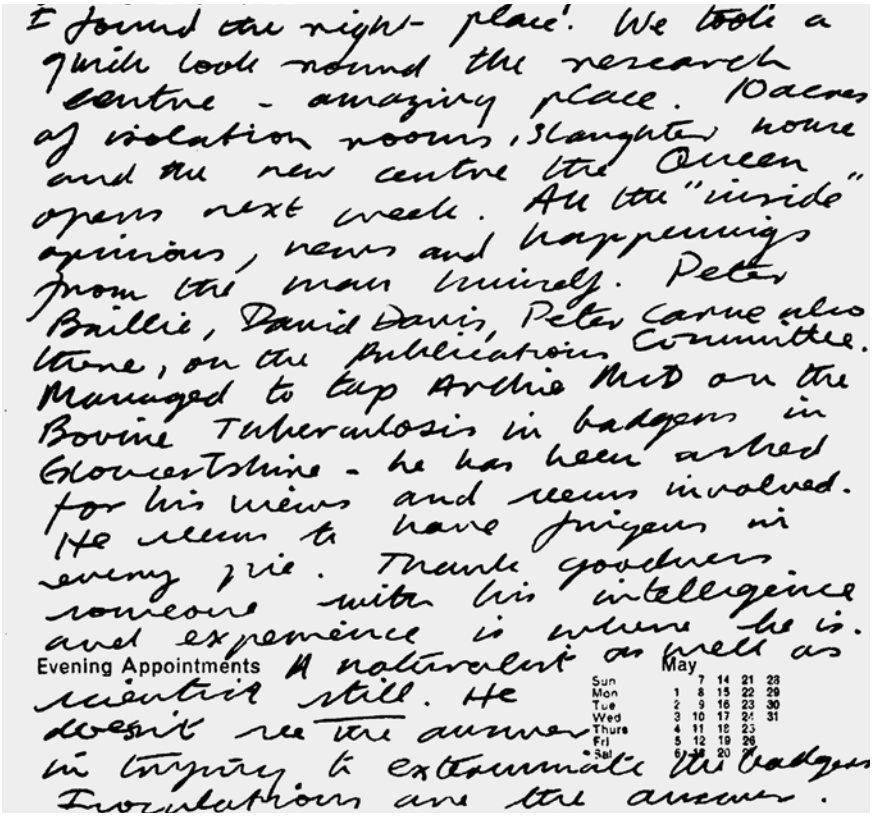


Figure 7: The distribution of badgers in West Penwith, 1972 (MAFF (1972), Appendix N).


I found the right- place. We took a
quick look round the research
centre - amazing place. 10 acres
of isolation rooms, slaughter house
and the new centre the Queen
opens next week. All the "inside"
opinions, news and happenings
from the man himself. Peter
Baillie, David Davis, Peter Carne also
there, on the Publications Committee.
Managed to tap Archie McD on the
Bovine Tuberculosis in badgers in
Gloucestshire - he has been asked
for his views and seems involved.
He seems to have fingers in
every pie. Thank goodness
someone with his intelligence
and experience is where he is.
Evening Appointments A naturalist as well as
scientist still. He
doesn't see the answer
in culling & exterminate the badgers
Inoculations are the answer.

May

Sun		7	14	21	28
Mon	1	8	15	22	29
Tue	2	9	16	23	30
Wed	3	10	17	24	31
Thurs	4	11	18	25	
Fri	5	12	19	26	
Sat	6	13	20	27	

problems that they were having in West Penwith, which at that time were quite severe. There was also information in that report about the number of badger setts in West Penwith and a guestimate as to how many badgers they thought there were in West Penwith (see Figure 7).[12]

Mr Michael Clark: Just as an outsider as it were at that time, in 1973 I went to Dr Archie McDiarmid's home in Compton, Berkshire.[13] I was a committee member of the Deer Society, of which I was a founder member, and the committee meeting was followed by a conducted tour of the new MAFF laboratories nearby – HRH The Queen was going to open the new buildings the following week. Not long before the meeting the news had come through

[12] The report stated there were about 370 badger setts and around 1300 badgers in the area; MAFF (1972), point 4:29.

[13] Dr Archie McDiarmid (d. 2011) worked at the Institute for Research on Animal Diseases, Compton, specializing in brucellosis and tuberculosis, until his retirement in 1980. He was Chairman of the British Deer Society and represented the Agricultural Research Council on the Badger Panel.

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Figure 9: Entry from Mr Michael Clark's diary (1973)

[14] See, for example, Clark (1970).

Figure 10: Dr Gordon McGlone and Mr John Montague

Society on the Badger Panel.[15] Dr McDiarmid also visited Woodchester Park[16] with these specialists on the Badger Panel. Whatever became policy later, that was his initial reaction to the problem as recorded in my diary in 1973.

Dr Gordon McGlone: I've lived and worked in Gloucestershire since 1979 and I encountered the subject 'badgers and bovine TB' almost immediately I started work with the Wildlife Trust. I left the Wildlife Trust last January. This week I have this meeting today, a meeting on Thursday evening, and a meeting all day on Friday on the same subject. I do welcome this gathering because I think this is a fascinating and very important example of how a subject can move from the back rooms where science – I'm a scientist – is carried out in a fairly unintentionally secretive way, through to becoming something that's

[15] The Consultative Panel on Badgers and Tuberculosis, comprising a panel of experts and representatives from interested organizations, ran from 1975 to 1997 to review the evidence of bovine TB in badgers and provide MAFF with advice on dealing with the problem. For discussion on the Badger Panel see pages 73–5.

[16] Woodchester Park is a Site of Special Scientific Interest in Gloucestershire owned by the National Trust, which has been used by the Wildlife Disease Ecology Team of the Central Science Laboratory (MAFF/Defra) since 1975 for research on naturally infected badgers.

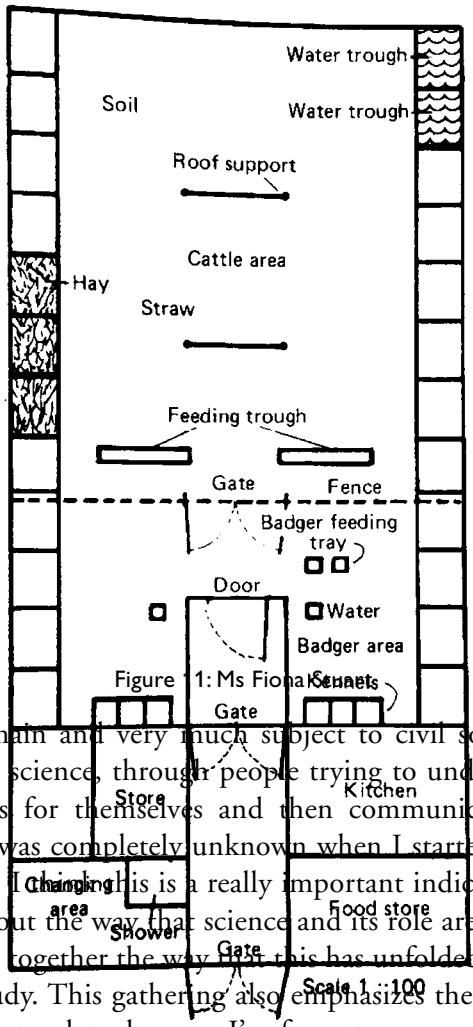

Figure 1: Ms Fiona Stuart's

in the public domain and very much subject to civil society direct action through to citizen science, through people trying to understand these really complicated issues for themselves and then communicate routinely with politicians.[17] This was completely unknown when I started work; it has now become the norm. I think this is a really important indicator, which can tell us an awful lot about the way that science and its role are going to unfold in the future. To pull together the way that this has unfolded is, I think, a really important case study. This gathering also emphasizes the need to get people together before it's too late, because I've forgotten more than I ever realised I knew, and at the time it didn't seem to matter. Now it looks as if it was perhaps relevant, but I can't remember dates and I can't remember the things which would help to put together the actual profile of how this unfolded.

Ms Fiona Stuart: Although Keith says I might remember 1972, I was at veterinary college then, and my father, Peter Stuart, was head of bacteriology at the Central Veterinary Laboratory, Weybridge, and I do remember the first badgers coming into Weybridge for experimental purposes. They were actually naturally infected badgers from the wild being put with calves in

[17] See further comments by Dr Gordon McGlone on pages 71–2.

Figure 12: Plan of the high security cattle yard. Reproduced from *Veterinary Record*, Little T W, Naylor P F, Wilesmith J W, 111, 550–7, 1982, with permission from BMJ Publishing Group Ltd.

a secure fenced concrete yard (Figure 12). That was the first demonstration experimentally that badgers did pass TB to those calves – the calves tested positive a few months later.[18]

I just remember the excitement, as a vet student, being able to go and see these captive badgers and my father talking about this increasing TB problem of not being able to get down to final eradication of TB in the West Country,

[18] Little, Naylor and Wilesmith (1982).

and John Gallagher finding the first TB badger at Gloucester in 1971.[19] I remember going to the Veterinary Investigation (VI) Centre and seeing him post mortem the badgers there, just on the open bench, of course, which wouldn't happen nowadays. Those are my memories from the 1970s; I didn't actually join Weybridge until 1979 and I was working on brucellosis to start with, but it was all certainly taking off around that time.

Clark: Can I just come back to the first point about why bTB is dangerous to humans when all milk is pasteurized.[20] My wife and I have many friends in farming, and one of our neighbours, Adrian Hill, insists on drinking daily glasses of non-pasteurized milk. I understand it is still not illegal in England and Wales to drink unpasteurized milk.[21] I think we are in one of the last places in the world where you can drink milk that's not pasteurized. Although bTB is not known in Hertfordshire, there is a danger that a farmer neighbour, living 250 yards from our house, may be infected with bTB from drinking milk.

Professor David Macdonald: I'm an ecologist. I think it's a really interesting issue, as you were saying, in terms of society's treatment of scientific evidence and the unfolding/understanding of ecology, which has taken place over the 30 years or so that we're talking about. To give a little perspective on the history of ideas, which maybe you'll want to explore later: my recollection of the beginning of the ideas that are currently important here, in my own experience, came from the mid- to early 1970s when I was working on foxes and rabies, with people like Harry Thompson, who was Keith's predecessor in some sense, in his roles, and Gwyn Lloyd, then a MAFF biologist working on foxes.[22] Happening to be in the right place at the right time, I came up with the idea that fox society was

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[19] Dr John Gallagher worked as a veterinary pathologist for MAFF from 1972. Working with colleagues, he conducted the first investigations of TB infections in wild badgers in the UK. He was Director of MAFF Veterinary Investigation Services for Devon and Cornwall, and when he retired he was appointed as Independent Adviser on TB to the Government's Chief Scientist's Group. The first badger infected with *Mycobacterium bovis* was discovered in Gloucestershire in 1971. Between April 1971 and April 1973, examination of 165 carcases of wild badgers showed 36 to be infected and, of 112 samples of faeces, 12 were infected. See Muirhead and Burn (1974); Muirhead, Gallagher and Burn (1976).

[20] See page 7.

[21] Unpasteurized (raw) milk can be sold in the UK directly from farm to consumer under strict hygiene and food labelling regulations; its sale was banned in Scotland in 1983. For the current legislation on raw drinking milk in the UK, see the government website at www.food.gov.uk/business-industry/farmingfood/dairy-guidance/rawmilkcream (accessed 27 January 2015).

[22] See, for example, Macdonald (1980).

Figure 13: Mr Michael Clark, Professor David Macdonald, and Mr Mark Thomasin-Foster

much more complicated than the World Health Organization had previously taken into account and that, when trying to control the transmission of rabies through killing foxes, a consequence could be a disruption of the behaviour of the survivors, which in turn could lead to an unintended increase in the spread of the disease.[23] In the late 1970s and early 1980s, in the Badger Panel, which in due course Keith and Mark joined, that idea started to mutate into what became known as the perturbation hypothesis, with respect to unexpected consequences of trying to control TB in cattle through killing badgers.[24] I remember, in about 1984, writing an article in *New Scientist* beginning to say this idea had some legs.[25] What's quite interesting is that at that time it was an unusual thought. Now it's commonplace and perfectly obvious that studying the behaviour, the societies, the ecology of disease vectors could give you an insight into ways of managing the disease.[26] The earlier ways of thinking had been more to consider

[23] Macdonald and Bacon (1982).

[24] The perturbation hypothesis has been developed from evidence showing that culling infected animals leads to disruption of their social organization and behaviour. The decline in numbers may encourage other animals to come into the area and infected animals to spread out, leading to an increased contact rate and spread of the disease. With reference to badgers and TB in cattle see, for example, Macdonald, Riordan and Mathews (2006).

[25] Macdonald (1984).

[26] Tuyttens and Macdonald (2000); Macdonald and Willis (2013).

these animals, if you like, as molecules bouncing around at random, so if there were fewer of them the contact rate would go down. It's a pretty straightforward thought. I would say that the ideas that are current at the moment (2014) started to gain traction in the early 1980s and then went through a very interesting period of being perhaps thought of as a bit eccentric and rarified, and it's interesting to see nowadays that any conversation about badgers and bovine tuberculosis has at its very heart notions of perturbation. It's a pretty obvious idea but I think it's quite powerful. So one can see how thinking about animals, societies, and ecology has, in all sorts of sectors, been transformed – as I say, for me it started in rabies and moved to badgers. The wider public and indeed the political body has greater appreciation of the many and complicated dimensions to these problems.

Montague: Picking up, to a certain extent, on both Keith and David. Keith started with West Penwith. My first exposure to TB was in 1979 at the other end of Cornwall where I was working until 1987. What one was seeing there as general practitioners was a situation where cattle were really acting as a sentinel of infection in another species, which we assumed at the time was badgers. You were getting breakdowns[27] on farms in specific groups of cattle, most of the testing was being done during the winter months and often the replacement heifers had been away at summer grazing, often on cliff land, and they were coming back into the milking herd in the late summer and autumn. You had a cohort going down with TB and we assumed that we were eliminating infection through tuberculin testing, and these herds were on annual testing, and they were coming back with TB over the years. There were good years and bad years where there would be less TB in one year, and more in another. It would be interesting to know what may have caused that. Were we dealing with ecological features? Were we dealing with a climatic situation? Or were we dealing with just removing infection and there may have been some badger control taking place at the same time? What's interesting is our understanding now through the molecular typing of *M. bovis*, which suggests that we had a series of mini-epidemics taking place concurrently and it isn't one homogenous epidemic. And if you accept the theory that the main driver for this transmission is from badgers, when were badgers infected? How long have they had to be infected to show that level of bacterial diversity? And if cattle were acting as sentinels for infection in badgers, what was the combination of circumstances that was taking place either in the 1970s or 1980s, or when we had another great wave of new epidemics, with new

[27] A breakdown is the evidence of tuberculosis in a herd of cattle; see the glossary on page xi.

Figure 14: Dr Richard Meyer

molecular types appearing in the late 1980s and early 1990s.[28] What were the circumstances taking place that resulted in that transmission manifesting? You can throw ideas around, we've already talked about changes in farming type, changes in the breed basis of cattle. I don't think we fully understand the individual animal risk factors or the herd risk factors or what drove the epidemic, either in the 1970s or the early 1990s, or in the post-2001 foot and mouth disease period. I know it isn't within your timetable, but something very significant happened to infection rates during foot and mouth disease, which we've never fully understood or explained.[29] Is that spread to cattle associated with farms? Is it associated with ecology and badger populations? Is it driven to a certain extent by perturbation and culling, the culling policies and illegal culling, because we just don't have a handle on the amount of illegal culling that takes place?

Dr Richard Meyer: I'd like, if I may, as suggested in the outline programme, to go back a little before 1970 to the 1960s. Although not directly involved in badger controversy then, I was living in north Cornwall at that time. The word then was that the reason there was, to quote Eunice Overend, 'a reservoir drying

[28] For further discussion on molecular typing, see pages 62–3 and note 137.

[29] See pages 33–4 and note 73.

up of TB' that ended up with pools in the South West was that the national herd was tuberculin tested.[30] I believe it started in the North and moved south. A lot of 'dirty' cattle were pushed down and ended up in the South West, which is one reason, this was a theory, why we were left with hot spots of TB in the South West. Allied to this, and this is only conjecture – I don't have any evidence for it, and maybe others here will be able to put me right – but the word was, that cattle were being imported from Ireland which were infected. So you had farmers moving down infected cattle and they were naturally coming south, the sort of dirt before the broom syndrome, and cattle coming in from Ireland which were possibly diseased. Coupled to the geography and the edaphic factors in the South West, maybe the higher acidity of the soil, there are fewer trace elements to counteract immunosuppression in the cattle in the pastures at that time. So I feel that, if there is anything in this at all, my question really is: Why weren't badgers reinfecting cattle earlier – after the Second World War, before the 1970s? If it was such a problem, why did it end up that the rest of the country could be cleared of TB, without badgers presumably reinfecting them? Why did it end up that it was just a problem in the South West?[31]

Mr Mark Thomasin-Foster: I came into this slightly later than the time you are talking about, in 1987. I think the Badger Panel at that stage was privileged in having the ability to take the science as its lead, and unfortunately as things transpired, the political will and the public interest started to take much more of the lead, whereas we should have continued to be driven by the science. I feel that was a great disappointment. Answering that last point, I've seen, over my experience, a great shift in the form of agriculture and agricultural management and I think perhaps that's not looked at closely enough.[32] Certainly from my own experience in Essex, and I know that was a clear bTB area, as soon as I started introducing the growing of maize, and maize for game shooting, which stays in the ground for quite a long time, I had a very significant badger population move in. Then the issue of haymaking against silage making; we're perhaps missing some of the indicators that we should be

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[30] In the UK compulsory testing for TB infection in herds of cattle was started in 1950. The resulting slaughter of infected animals reduced the incidence of TB in herds to a low level though this was not uniform across the country with levels of TB in the South West remaining little changed.

[31] See comments by Mr Keith Meldrum on pages 29–30.

[32] A similar point about the impact of changing agricultural practices was made by Miss Mary Brancker and Lord Plumb at the Witness Seminar on foot and mouth disease; see Reynolds and Tansey (eds) (2003), pages 34–5.

Figure 15: Mr Mark Thomasin-Foster

looking at, and we should learn from, as to how agriculture changed over the 1960s, 1970s, and 1980s. I think that's important.[33] The one thing that I don't hear very much about and would love a clearer answer on, and we lived with it through my time on the panel, and that is the question of Steeple Leaze and Thornbury, and the experiments done there. Thornbury, I'm not sure about Steeple Leaze, was of course a gassing area, and I just wonder whether again that's something we haven't looked at closely enough and there are things that we could learn from that as we take this issue forward.[34]

Macdonald: Two quite separate points. The first, picking up something John and Mark said about things that might be affecting badger populations – the nature of farming, and this point will allow me to extoll the virtues of long-term studies. It's become clear over more than 20 years now of studying badgers in a couple of very intensive study areas in this country – one in Woodchester Park monitored by Defra, and one in Wytham Woods, which is my own territory – that we've been able to understand things about badger demography that provided a backcloth to interpreting many things. When

[33] For agricultural practices and bovine TB see, for example, Reilly and Courtenay (2007).

[34] Systematic badger clearances were carried out at Thornbury, Gloucestershire and at Steeple Leaze, Dorset between 1975 and 1981. See the discussion on pages 56–8.

John asks what might have changed, among the many things that might have changed, as well as the common agricultural policy and other things that affect the farmscape, is the climate. There's now very compelling data, largely published by my team, of badger populations and indeed their organization being affected by the amelioration of the climate in our study area, that has led to an approximate trebling of the badger population over the last 30 to 40 years, and two-stage phase shift in their organization.[35] So I just wanted to say, in passing, that the details of animal ecology have unfolded and in terms of government policy, understanding the merits of long-term data sets is something that time and again is demonstrated and time and again ignored.

In the spirit of setting out something from an ecologist's point of view, I'd also like to think about, if I might, the history of ideas. I'd like to comment briefly on things that we've done well and things that we've done less well, and see what colleagues think about this. It seems to me in this story that there have been some really quite outstanding pieces of science done in animal ecology. While it's commonplace in the press for people to say: 'Oh we just don't know about this, that, or the next thing', actually we know the most enormous amount, after 20 or 30 years of work, about the relevant animal ecology. That includes the so-called Krebs trial of interventions in badger control, which probably is one of the largest and most comprehensive field experiments ever undertaken anywhere.[36] So we should be aware that a lot of the science has been done very well in that way. Something I think we've got repeatedly wrong from the very beginning, and continue to do so, is the joined-upness of all of this. Somebody made a remark a few moments ago about the importance of trade in cattle and aspects of wider commerce and economics that affect these issues. Although there have been attempts in the various reports over the years to bring in the social sciences of economics and so forth – important attempts, I don't diminish them – I think we're still not terribly good at the wider, economists would call it the 'full life-cycle', analysis of all the factors that come together and put a broader perspective on questions like: just how important is the badger part of it? Just how important are the economics of cattle trade? Just what are the economics of farming that affect how we might look at land use change? My money says that the solution to this almost intractable problem will come from a better interdisciplinarity that creates a wider interdisciplinary perspective.

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[35] See, for example, Macdonald *et al.* (2010).

[36] The 1997 Krebs review led to the Randomised Badger Culling Trials (RBCT) which ran from 1998 to 2005. See further discussion on pages 35–6 and 76–9.

Figure 16: Mr David Williams

Stuart: Yes, I absolutely agree with what David was saying about the long-term nature of the problem and the importance of interdisciplinary collaboration, overseeing the whole TB problem in an interdisciplinary way. I was just going to mention a bit about Woodchester Park, which I was involved with very closely for many years. I think originally it was set up in the mid-1970s and it's a pity that Chris Cheeseman couldn't be here because it was basically his life's work.[37] But that's the sort of illustration of the need for a long-term study not only to look at the ecology of the badger but also, of course, because we mustn't forget that TB is a very chronic disease and it's also very difficult to diagnose, especially in badgers but also in cattle, humans – all mammals. I think a lot of the public perception is that it's a disease like influenza or more acute diseases that perhaps they're used to hearing about. That is a thing that we need to take into account when understanding the nature of the whole epidemic – it's a long-term, chronic disease, which you can only understand really in hindsight looking back over several decades.

Mr David Williams: Just to reply to what Mark was saying, there are a lot of things to be taken into consideration, particularly the weather, the climate, and the soil conditions. They've been overlooked, really, and what David said

[37] Dr Chris Cheeseman is a wildlife biologist and was head of wildlife diseases at the Central Science Laboratory (now the Animal and Plant Health Agency).

about the badger numbers, unfortunately what tends to happen is that we almost farm badgers in places in the West Country. We have short pasture, well fertilized, grow lots of maize, all things badgers love, and if there's more food you're going to have more badgers. No two ways about it. I also think we've concentrated too much on badgers; we should be looking more into the cattle, cattle that can have some sort of immunity. I think they're just starting to do that now, I'm not sure. And a question I wanted to know is: do we know what the incubation period is in cattle for TB?[38]

McGlone: I can't answer your question, David, but I just wanted to put in a sort of historical layer. In 1979 when I started with the Wildlife Trust, I had a very memorable day when Solly Zuckerman turned up in our office in his car with his chauffeur and my then chairman, Morley Penistan, who was a member of the Advisory Panel, was the Trust Chairman.[39] This gave me a grounding in this whole subject because I was able, on a regular basis, to be updated whether I asked for it or not, on the thinking behind the problem, the dots on the map which were small and isolated. I think that map is the most scary thing of all that I've watched change colour over the last 30+ years.[40]

But in terms of meeting Solly Zuckerman, the reason I bring that in is that Eunice Overend came to the office that day and, in terms of oral history, people like Eunice do need to be put in the map. You can also find an interesting piece about her in Peter Scott's book, *The Eye of the Wind*, because she was one of the early shapers of the Severn Wildfowl Trust.[41]

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[38] See pages 31–2.

[39] Solly Zuckerman, Lord Zuckerman (1904–1993) was Professor of Anatomy at Birmingham from 1943 to 1968; Chief Scientific Adviser to the Government from 1964 to 1971, and President of the British Industrial Biological Research Association from 1974; see further biographical details on pages 98–9. Morley Penistan (d. 1986) was a forester who, after his retirement in 1974, turned his attention to nature conservation, serving on committees such as the Badger Panel Farming and Wildlife Advisory Group, and was Chairman of the Gloucestershire Wildlife Trust.

[40] For maps showing the increase and spread of TB between 1986 and 2010, see Defra (2011), Figures 1 and 2, pages 12–13.

[41] Sir Peter Scott (1909–1989) was an ornithologist and artist. He founded the Severn Wildfowl Trust (now the Wildfowl and Wetlands Trust) in 1946 at Slimbridge, Gloucestershire. His autobiography, *The Eye of the Wind*, was published in 1961 (Scott (1961)). Eunice Overend was a retired biology teacher, naturalist, and activist. She was the first curator at the Severn Wildfowl Trust after the war; see pages 95–6 for further biographical details.

Act and were found guilty of 'unlawfully digging for badgers and attempting to take a badger away'. This was the first prosecution under the Wildlife and Countryside (Amendment) Act of 1985, which required defendants to prove that they were not digging for badgers instead of the prosecution having to prove that they were. Information supplied by Dr Gordon McGlone, email to Ms Caroline Overy, 8 May 2015.

Figure 17: Representatives from Wildlife Trusts with Tony Banks MP, lobbying the House of Commons, July 1990. Photographs supplied by Dr Gordon McGlone and reproduced with permission of The Wildlife Trusts

Thomasin-Foster: Just to take up David Macdonald's point a second ago: we spent a lot of time in the Panel looking at the figures of 1976 and wondering why, because of that very, very dry year, the numbers of breakdowns absolutely shot down (Table 2). We never actually resolved that. We thought it was the dry year, but again is this something to do with the climate change you mentioned a minute ago, or is it farming practice or what is it? I'm sure there's been work done on that, but I keep on saying, are we not missing tricks that should be telling us a lot more than we have gathered. Going back to the remark I made a few minutes ago, I would suggest that, unfortunately, the political side is driving this too hard.[44]

Table 2: Number of cattle reacting positively to the tuberculin test in south-west England between 1973 and 1978[45]

Clark: There are two things that have come up I would like to comment on: Professor Zuckerman and the gassing of badgers that Mark referred to. The Zuckerman Report was quite a significant document as far as I was concerned as a Panel member.[46] I had already brought it to the attention of fellow Panel member Dr Harry Thompson, whom David has mentioned. Dr Thompson was a distinguished and well-liked member of the Mammal Society, whom I greatly respected. I showed him a picture of a badger a gamekeeper local to us had told me about. He had been gassing rabbits and foxes and was upset he had also killed a badger. I went to the site and found it at the entrance to a sett where it had died struggling to dig out. It had soil in its mouth and contorted features. I took a photograph of it and I later published this in a paper on the conservation

[44] See page 20.

[45] Figures taken from Zuckerman (1980), Appendix 1, online at www.bovinetb.info/docs/zuckerman.pdf (accessed 13 April 2015). See the discussion on pages 32–3.

[46] In 1979, following public pressure, the Minister of Agriculture, Peter Walker, suspended gassing and commissioned Lord Zuckerman to undertake a review of the bovine TB problem; see Zuckerman (1980). The gassing of badgers became illegal in 1982.

of the then unprotected and widely persecuted species in our local journal.[47] I showed this picture to Dr Thompson at one of the Panel meetings and he said at the time: 'Oh, it cannot have died in any anguish because badgers have been tested at Porton Down, where we do all our testing on how animals react to the gas.' His lifelong work was in rabbit control, which involved advice in the safe use of Cymag, the ICI standard product sold.[48] He was famously known for swerving his car to miss a rabbit in the road, having spent a lifetime working out ways of gassing them! Professor Zuckerman, when preparing his report, asked to see the evidence of how badgers reacted to being gassed and at that time it was found that badgers had *never* been tested at Porton Down after all. In fact when they did test badgers being gassed by cyanide, it was seen that they do not die as foxes, dogs, and rabbits. I've never seen the observations actually published, but it was reported to me afterwards that they have severe respiratory reaction and they do not die quickly in the manner of other tested species.[49] During all the years of surveying setts I used to find lots of old tins of Cymag left and it was clear that a lot of people were using, or misusing, hydrocyanic acid gas. Burrows could be pump gassed but gamekeepers generally put the powder into the entrance of the sett and then closed soil over the powder, which sent off a lethal cloud in the damp tunnel air. It was very dangerous if stored carelessly in vans and some keepers died because the tins rusted and minute holes released the fumes. Gassing became officially illegal after the Zuckerman Report, although I understand it has been recently revived as a proposal by HRH, the Princess Royal, as being a solution to the problem.[50] I think HRH is possibly muddling it with the illegal use of carbon monoxide, which is known to be done by farmers, keepers, and landowners who pipe their exhausts from vehicles into setts to kill off occupants of fox earths and badger setts.

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[47] Clark (1970).

[48] Cymag is a fast-acting poison that releases cyanide gas on contact with moisture. Its use was banned in the UK in December 2004.

[49] Lord Zuckerman reported that the speed at which hydrogen cyanide kills at different concentrations, which, although it was known for some species, was not known for badgers (Zuckerman (1980), page 94). He therefore recommended that experiments be carried out at Porton Down to examine the toxicity of hydrogen cyanide to badgers and the humaneness of using this method. Ferrets were used as a model for testing as badgers were not easily available. See the report by the Chemical Defence Establishment, Porton Down (1982).

[50] The Princess Royal, who had lost 15 of her rare breed cattle to bovine TB, said in an interview to the BBC in April 2014 that gassing was the most humane way of controlling badgers. See Weaver (2014).

Meldrum: There are about ten things I could say but I will restrict my comments at the moment to the early days and leave until later the time in 1980s when I was involved with a host of Ministers about tuberculosis control and eradication policy: I'll leave that until later in the day because there are some very interesting things that came out of that. On the issue of why we had so much tuberculosis in cattle, particularly in Cornwall, particularly in West Penwith, we concluded at that time, and I think it's fair comment, there was a very significant amount of cattle movement from farm to farm.[51] Unless you have synchronized testing in a whole area, which we did not have at the time, you're going to get animals that are incubating disease moved from one farm to another. That was one thing certainly that came out of the West Penwith study, and I think it would have come out also from the work done in the epidemiology unit at the Central Vet Lab with Gareth Davies, John Wilesmith, and Richard Clifton-Hadley.[52] So we had concerns about movement of cattle from farm to farm, synchronized testing,[53] and also very poor fencing between farms.[54] In fact the whole of West Penwith was one large herd of cattle and it was not surprising really that, at that time, there was a great deal of tuberculosis in various parishes, just moving from parish to parish. It comes up later in the context of how much money you can pump into the tuberculin testing programme in an area or a county or a region or on a national basis. On the possibility that cattle from Ireland might be bringing in additional tuberculosis, I don't think that was the case. I haven't seen that in any of the reports I saw in

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[51] The 1972 MAFF report states that 'a significant number of cattle sold in West Penwith are traditionally purchased by other stock owners in this area, so that there is an element of "recirculation" within the area itself'. (MAFF (1972), point 4.37).

[52] Professor John Wilesmith worked at the Central Veterinary Laboratories from 1976 and was Head of the Epidemiology Department from 1986. Dr Richard Clifton-Hadley worked at the Animal Health & Veterinary Laboratories Agency (AHVLA) and was the Manager of the Statutory and Exotic Bacterial Diseases Programme from 1997 to 2012. This programme included all projects to do with bovine tuberculosis, including epidemiologically-based projects. Each project had its own project leader (information on Dr Clifton-Hadley supplied by the Animal and Plant Health Agency, email to Ms Caroline Overy, 17 June 2015).

[53] '…the clearer understanding of the distribution of reactor herds in which there is additional evidence of tuberculosis indicates that it would be both practical and desirable to synchronise tuberculin tests within defined areas, in such a way as to include the maximum number of such herds and others at immediate risk.' (MAFF (1972), point 4.10).

[54] '…the poor standard of fencing in the West Penwith area which frequently allows contact between neighbouring stock is a major factor in the perpetuation and spread of tuberculosis.' (MAFF (1972), point 4.5).

earlier days.[55] Because, of course, all movements were controlled by EU Directive 64/432, which requires that these cattle would only be entering the country when they had tested negative for tuberculosis.[56] So, I don't know anything about Cornwall becoming a sump. I do know that after we had foot and mouth disease in 1967/68, we had a massive problem of brucellosis in Cheshire because, at that time, government didn't take a view that cattle moving into these depopulated farms should have been brucellosis-free. Well, we missed something there and I think a similar problem occurred in 2001 with tuberculosis on restocking, when I had retired by the way, after foot and mouth disease.[57] Today, I'm not going to get into ideas of what may have happened; I'm going to stick to the facts as far as I knew them at the time. I could make all sorts of guesses as to why the problem is so much worse. But Gareth's interesting question, the first question he raised, about why:[58] well, I think today we know why – because the disease is in cattle, 37,000 cattle were taken out with tuberculosis in 2012, that sort of number, it's a very, very high figure.[59] So in animal disease terms alone, Gareth, I would say the programme must continue. Of course, anyway we're bound by rules in Brussels and Directive 64/432 does cover control of tuberculosis in great detail.[60]

Macdonald: It occurs to me that another thing that has been quite important in this history, as of course it always is, is the timing of methodological breakthroughs that have allowed science to take a bit of a hop forward and change thinking. It strikes me that as all this has unfolded there's probably an

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[55] See comments by Dr Richard Meyer on page 20.

[56] 64/432/EEC is the 'Council directive 26 June 1964 on animal health problems affecting intra-community trade in bovine animals and swine'. See http://eur-lex.europa.eu/legal-content/en/LSU/?uri=CELEX:31964L0432. The British Cattle Movement Service maintains a database of all cattle in the UK (the Cattle Tracing System) on which all births, movements, and deaths of cattle must be recorded.

[57] It is thought that, following the slaughter of cattle infected with foot and mouth in 2001, herds were possibly restocked with cattle infected with bTB; see, for example, Carrique-Mas, Medley and Green (2008).

[58] See page 7.

[59] Statistics released by the Agricultural Departments of Great Britain in March 2013 revealed that between January and December 2012, 37,753 cattle were compulsorily slaughtered (http://webarchive.nationalarchives.gov.uk/20130315143000/http://www.defra.gov.uk/statistics/foodfarm/landuselivestock/cattletb/national/ (accessed 3 December 2014).

[60] See note 56.

interesting historical perspective to say that it was in the very early 1970s that the very first radio tracking of animal movements was done in this country. I think the first two people to do it were the aforementioned Gwyn Lloyd and myself, and it was later in the 1970s when Niko Tinbergen got his Nobel Prize for animal behaviour and very kindly gave his prize money to Hans Kruuk and myself to buy the first pair of infrared binoculars to be used in night vision work in this country.[61] These are sort of serendipitous things about methodological breakthroughs that none the less allow a new level of understanding. Looking at other breakthroughs, at monoclonal antibodies, DNA fingerprinting, gamma interferon, breakthroughs in what the science could do, they'd caused a little surge in the way people think. Similarly, epidemiological modelling – the Anderson and May models of how the behaviour of individuals can lead to the changes in the behaviour of diseases, landscape ecology today.[62] So other strands in this unfolding story are these sorts of little saltations caused by methodological breakthroughs.

Meyer: Gordon mentioned Eunice Overend, and I did myself a little while before.[63] She was, of course, one of three formidable ladies – herself, Jane Ratcliffe, and Ruth Murray, down in Dartmoor, who were heavily involved in the 1970s and 1980s.[64] In 1980, Eunice produced a booklet, *Badgers in Trouble: what's to be done about it?*, which includes a piece about gassing, her perspective then, in the 1980s, and also a review of the Zuckerman report.[65]

Stuart: Just to go back to an earlier question about how long is the incubation period of TB:[66] that's one of the great unknowns because many of the

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[61] Nikolaas Tinbergen was awarded the Nobel Prize in Physiology or Medicine in 1973 (jointly with Karl von Frisch and Konrad Lorenz) 'for their discoveries concerning organization and elicitation of individual and social behaviour patterns'; see www.nobelprize.org/nobel_prizes/medicine/laureates/1973/ (accessed 3 February 2015). Tinbergen was tutor to Hans Kruuk who, in 1972, with David Macdonald (his doctoral student), set up a long-term study of the badger population in Wytham Wood.

[62] See, for example, Anderson and May (1979a and b).

[63] See pages 19–20 and 24–5.

[64] Jane Ratcliffe (1917–1999) was a naturalist and wildlife campaigner, known for rescuing injured animals and fighting for badger protection. Ruth Murray ran a badger sanctuary on Dartmoor for many years. For an overview of the early badger protection campaigns see, for example, Barkham (2014).

[65] Overend (1980).

[66] See page 24.

diagnostic tests that we use, in all species really, may be measuring exposure rather than infection. One can never actually know if that goes on to then develop into full blown disease if you then kill the animal or it's lost to follow up in some way. TB is a chronic disease, so it's usually not going to be a matter of hours between exposure and infection. The dogma is, especially in human TB, and one assumes animals, that it requires prolonged, close contact to become infected, although obviously that isn't always the case depending on the individual. It's one of the huge problems of working on a disease like this in the veterinary and scientific side, because you can't actually answer the question of when the animal became infected.

Montague: Just to expand on some of the remarks that Mark made, and I'm afraid I can't answer many of them, Mark, but your list matches so much of what I jotted down on my way here. You talked about the dry summer of 1976:[67] what's interesting is that we did change the diagnostic test in 1975, when we changed to bovine PPD (purified protein derivative), which should have improved sensitivity.[68] If you look at the data, the graphs, you can persuade yourself that that resulted in identification of a greater number of infected animals. The difficulty with TB statistics is we do try to read them over too short a timescale, and I'm never convinced whether the changes are true statistical variation or whether it is just a reflection of our surveillance programme, especially at the time when we didn't have the vast majority of the country on annual testing. So much of the increased incidence occurs when you start to do increased levels of testing in a new area – herds that were previously tested every four years are now coming round on an annual cycle. It's a bit like the recent Wales story: when the Welsh suddenly, for two or three years, put in an annual test, they showed a worsening disease picture, and now they're showing an improving disease picture (see Table 3).[69]

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[67] See page 27. The summer of 1976 in the UK was the hottest on record, with the country suffering a severe drought.

[68] Prior to 1975 the diagnostic tuberculin test was made from *Mycobacterium tuberculosis*; in 1975 a test was developed using *Mycobacterium bovis*, which increased specificity and reduced the number of false positives. See Lesslie *et al.* (1975).

[69] Since 2008 all herds in Wales have had a minimum routine testing frequency of a year. Those located within the Intensive Action Area in south-west Wales have been subject to twice-yearly testing since January 2010.

Date	New TB incidents	Number of cattle slaughtered
2008	1,198	11,401
2009	1,186	11,671
2010	1,039	7,619
2011	1,045	8,068
2012	1,112	9,288
2013	875	6,102
2014	851	6,379

Table 3: Incidence of bovine TB in cattle in Wales, 2008–2014[70]

We don't know whether that's a true reflection of the prevalence of disease or whether it is actually just a reflection of surveillance. So we had tuberculin that changed, and my understanding of tuberculin increased quite dramatically while I was in Defra in the last 10 years; it's a pretty variable product. The sensitivity and specificity between batches vary, I would suggest, quite considerably, and much of the change in surveillance data over the years may be due to differences in the performance of the diagnostic test. But you also brought up why in the dry summer? Some people might say it had an impact on earthworms so it might have had an impact on badger populations, and that's one train of thought.[71] Another one is what is the impact of other cattle diseases on the bovines being tested? Dryer summers, less liver fluke? What does fluke do with regard to how animals disclose to the diagnostic test?[72] I think this is the difficulty with tuberculosis: we can develop lines of argument around many of these things but it is very difficult to establish categorically why any situation occurred because of a specific something. It came up very much during the Randomised Badger Culling Trial (RBCT) and postulating about cause and effects. Fiona, you might have to remind me, but we had a lot of theories why, when we came back to trial work after 2001 foot and mouth, there were some issues around the level of infectivity in badgers; because in the pre-foot and mouth disease trial badgers, some only had a prevalence of about 3 per cent infection and then after foot and mouth we had prevalences

[70] Data taken from the Bovine TB Eradication Programme on the Welsh Government's website at http://gov.wales/topics/environmentcountryside/ahw/disease/bovinetuberculosis/bovinetberadication/?lang=en (accessed 5 May 2015).

[71] Earthworms are a major part of a badger's diet; see, for example, Kruuk (1978).

[72] A study of over 3000 cattle in England and Wales showed that there was a negative correlation between liver fluke and diagnosis of bovine TB (Claridge, Diggle and McCann (2012)).

of about 14 per cent. We were looking at why, and very much the work of Rosie Woodroffe was to apply a whole load of concepts and to see what possible cause fitted the data best.[73] Unless you're actually capturing all this data, it's very difficult to be categoric, or not even categoric, to find the line of best fit from the data to the various theories.

Stuart: So your question to me was why the prevalence went up after foot and mouth?

Montague: Can you remember the issue within the Independent Scientific Group (ISG) in about 2003/2004 while we were trying to fit an explanation to the data on badger prevalence?[74]

Stuart: Yes, I can certainly remember all the discussion around it. The other thing that we need to remember is that TB does naturally, it seems, cycle up and down, so it might have just been something that was happening anyway, but there were various theories. I remember Rosie Woodroffe was very adamant at one point about looking at the North Atlantic Oscillation effect, which I suppose is affecting the changing climate to some extent.[75] They were coming up with all these theories – well, we were as a group really. Then the perturbation effect, which David mentioned, was gaining a lot of traction, as the theory that was looking the most likely to be an explanation for the increasing prevalence in badgers.[76] Proving any one of those theories as the actual explanation is a different matter. I'd have to look back at the actual report, and I suppose the minutes of the ISG, which are available if anyone

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[73] Professor Rosie Woodroffe is Senior Research Fellow at the Institute of Zoology, ZSL, London (since 2007). Her research focuses on conservation, infectious diseases, and animal behaviour. During the foot and mouth outbreak in 2001 routine cattle testing was suspended for ten months, delaying the removal of infected animals, and RBCT field work in the trial areas was also suspended. Associated with the delay was a marked increase in the incidence of *M. bovis* in cattle and badgers. See the summary in the final report of the Independent Scientific Group for Control of Cattle TB (2007), page 84, and Woodroffe *et al.* (2006). See also Mr John Montague's comments on the Road Traffic Accident Survey on pages 41–2 and note 92.

[74] The Independent Scientific Group was formed in 1998 to oversee a randomized trial to test the effectiveness of badger culling as a means of controlling bovine TB. The final report was published in 2007 (Independent Scientific Group for Control of Cattle TB (2007)).

[75] The North Atlantic Oscillation (NAO) effect is a result of fluctuations of atmospheric pressure over the North Atlantic Ocean influencing climate and ecological processes. For the investigation of the relationship between the NAO and TB in badgers, see Woodroffe *et al.* (2006).

[76] See note 24.

wants to look at them all, to know the actual record of the discussions that did take place.[77] There were quite a few theories being bandied around for at least a year, if not more, before perturbation became the main one.

Macdonald: Just a tiny bit more insight into that sort of thing. I remember at the time there was a vogue, and it has resurfaced again recently and I'm sure correctly, for speculating on the illicit behaviour of farmers at times when there was less access to the ground either for Defra officials or indeed a wider public. So some of the debate was about whether farmers were unilaterally killing badgers that might have a perturbation effect, in the same way that has now been demonstrated, or at least the evidence fits perfectly with a perturbation explanation, in the reactive areas of the trials.[78] Just to remind you that in the RBCT, the Randomised Badger Culling Trial known as the Krebs trial, there were three treatments, and one of them bears very much on what Fiona just said: there was the 'do nothing and see what happens' – a control in the scientific sense; there was the one where proactively badgers in these large 10 by 10 km^2 areas were killed as thoroughly as could possibly be done. And, by the way, that thoroughness varied radically in one of our own study areas within that trial. It was something like 34 per cent of the badgers were killed by the officials so one could see that it wasn't always effective; and then controversially, or interestingly and revealingly, there was the so-called reactive one, and I think that's what was very much behind what Fiona was saying where, if there was a breakdown in cattle within the 10 by 10 km^2 then the officials would go in and try to remove the badgers in that part of the square. That was discontinued after a while because early analyses suggested it was already making things worse rather than better. Then there was a long controversy and, for example, Charles Godfray I think was one of the sceptics.[79] I mention Charles just because he, Angela McLean, and I, and a couple of other people wrote a general review of the evidence in *Proceedings of the Royal Society* last year.[80] Anyway, there was some scepticism as to whether that trial had been stopped prematurely

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[77] Some of the records of the Independent Scientific Group can be accessed at the UK Government Web Archive at http://webarchive.nationalarchives.gov.uk/*/http://www.defra.gov.uk/animalh/tb/isg/index.htm (accessed 15 June 2015).

[78] See Cross *et al.* (2013) for a recent investigation of the illegal killing of badgers by farmers in Wales.

[79] Charles Godfray was Professor of Evolutionary Biology at Imperial College London from 1995 to 2006 when he was appointed Hope Professor of Zoology (Entomology) at the University of Oxford.

[80] Godfray *et al.* (2013).

and whether the apparent perturbation effect had been an artifact. But latterly, Christl Donnelly, I think the most forefront epidemiologist who has been analysing these data, and the aforementioned Rosie Woodroffe, have published a couple of papers suggesting that there really is pretty good evidence for a perturbation effect in these reactive areas, causing things, in the short term, to get worse.[81] Those data have been terribly important in the more recent analyses of the rolling out of current control schemes and the size that these areas needed to be to minimize a perturbation effect and so forth. So again one can see a change through the history of ideas gaining traction and affecting what's done.

McGlone: Just to add in some personal memories, my first encounter with the term 'perturbation' was a meeting held at the Ministry of Agriculture offices in Exeter in the early 1980s, attended by Eunice Overend, Hans Kruuk, and Chris Cheeseman. Eunice was actually talking very volubly about perturbation and not necessarily getting a total reception from everyone in the room, as the nature of her style meant that she didn't actually have the credibility she deserved. But clearly it had been picked up.

In terms of scientific evidence I think one of the great data sets that sadly was abandoned, was road casualty post mortem. There's a huge metadata source there that's kind of fragmented in terms of, not just badgers, but other species, which people are always asking about.[82] The point is the strategic direction of research. We are mulling over questions today about research evidence, when those questions were presumably being asked 30 years ago. There is a point as to how funding is directed into the research stream to generate the data which is then helpful to the setting of political direction. That's really interesting because there are some great big data sets at the moment that I'm aware of, and there's no funding going in to looking at them because it's down to money. Decisions about money and funding, particularly government money, are delicate and it would be very interesting to look at that as well. This is with

[81] Professor Christl Donnelly is Professor of Statistical Epidemiology at Imperial College London. Her research focuses on the statistical and biomathematical analysis of the epidemiology of infectious diseases. For her analysis of the RBCT data with Rosie Woodroffe, see, for example, Woodroffe *et al.* (2009). See also the discussion on pages 53–5.

[82] The road traffic accident survey of badger carcasses was initiated in 1972 and was abandoned in 1990 for reasons of cost. After that badger carcasses were collected and tested only on an ad hoc basis. The Krebs report of 1997 recommended the reintroduction of the survey in restricted areas. See the discussion on the RTA survey in the Krebs report (Independent Scientific Review Group (1997)).

hindsight, of course; at the time they were just dead badgers. I was banned from bringing dead badgers home after having one at the end of my drive for a while. My family stopped me so I have to say no more dead badgers turned up at my house.

Clark: Can I pick up on the mention of badger road casualties? During the 1970s when I was studying the species, just about every road casualty that was noticed in Hertfordshire tended to be brought to my notice for the records, and I prepared a number of these as flat skins to see how the colouring varied from season to season. Apart from local erythristic (red to nearly albino pelage) variations, the colours were surprisingly consistent and with their data, all are now in the Mammal Section collection at the British Museum (Natural History).[83] As a dutiful member of the MAFF Badger Panel I then took the dead badgers reported to me to the MAFF offices in Hertford for them to test for TB because everybody was worried where it was going to turn up next. In the end they said: 'Don't bring us any more badgers please; there's no TB in Hertfordshire and there's no TB in the cattle or the badgers here, so do not bring us any more.' Despite breakdowns all over the UK due to cattle movements, this appears to be still the case, but our farming friends are very concerned. John Wallace, one of the biggest landowners in the county, feels angry that the test itself has hardly been changed in the last 80 years or so and poor success may mean the disease arrives at any time. What worries all those I speak to is that they do not have anything that can give them a 100 per cent safe test of their cattle – it is still only about 80 per cent accurate. It has been very interesting to hear the comments made by Fiona, and so forth, about the difficulty of testing. But that is what happened with the road casualties in Hertfordshire and my experience of the views of farmers in the county.

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[83] Mr Michael Clark wrote: 'The road casualty badgers I collected were sometimes in good enough condition to be skinned and these were preserved for me by Rowland Ward in London. After research at the Natural History Museum in Kensington in the 1980s and 1990s for my book on Hertfordshire mammals, reptiles, and amphibians, I found it so valuable to refer to their material I thought it helpful to contribute my own Hertfordshire material I had kept for others to work from in the future. The preservation in the Museum's very professional temperature and pest-controlled conditions was also a consideration. They accepted the collection. I had also got to a point where I felt I had enough examples of the variations in the pelage of badgers to not need any more examples and by this time I was also delivering the road kills to the Ministry of Agriculture offices in Hertford as whole animals until they said there was no need to have any more tested as there was no bTB in Hertfordshire badgers or cattle.' Email to Ms Caroline Overy, 4 March 2015.

Meldrum: Can I just put the road casualty issue into context? I was around at the time. I was Chief Veterinary Officer (CVO), I think, at the time that decision was taken. It may surprise you to know that even in the 1990s, MAFF, for whom I worked, were short of money. Every year we had to go through cutbacks, and I didn't like it at all. We lost the health schemes; we lost a lot of work that had to go to the private sector because every year the amount of money for staff and resources, or staff and their expenses, was cut back. At the same time, don't forget, we had a disease called bovine spongiform encephalopathy (BSE) to deal with, and that was extremely expensive.[84] All the research money that went into BSE came from other programmes. The staff at the Central Vet Lab had all their budgets plundered, and whenever government said: 'Ah yes, we've got £4 million to put into BSE', yes, they had, but that had come from somebody else's research project, so we were under massive financial constraints at the time. The advice that I received at that time was that the road casualty work was not cost effective. Was it delivering useful additional information? It was expensive – you had to collect the carcasses for a start, then the post mortem thereafter, done by John Gallagher or somebody else, and then the bacteriology in Fiona's department, which is also very cumbersome and takes a long time. So it was an expensive programme and we had to make cuts and the road casualty work was one that we cut, but it was looked at, and every decision was looked at, very carefully; pros and cons. We concluded at the end of the day that this was one programme that we could do without because it wasn't producing any useful additional information. We knew at that time where there were problems of tuberculosis in badgers and would we add to that information by doing a lot more screening of badgers outside those areas? And, by the way, we must also remember – I haven't got the detail in front of me, although I've got the CVO reports still at home (I've kept them for a few years now because they're quite useful background information as to what we did because my memory is not perfect by a long way) – that we did other work on various trials, particularly in the early 1990s. In 1993 we put

[84] Bovine spongiform encephalopathy (BSE) is a neurodegenerative disease affecting cattle, which is transmitted through contaminated meat and bone meal supplements in cattle feed. It can be transmitted to humans as variant Creutzfeldt–Jakob disease (vCJD). Cases in cattle were first confirmed in the UK in 1986 and in March 1996 the Government announced that there was a probable link between BSE in cows and vCJD in humans. An inquiry was set up in 1998 'to establish and review the history of the emergence and identification of BSE and variant CJD in the United Kingdom'. At the time of the report in September 2000, there had been over 80 cases of vCJD in the UK, 170,000 cattle in the UK had been diagnosed with BSE, and over 4.7 million cattle had been slaughtered (Phillips, Bridgeman and Ferguson-Smith (2000),volume 1, page 2).

in place a new research programme at the Central Vet Lab particularly looking at badger vaccines, which by this time you were there, weren't you, Fiona? A group of badgers was established at the Central Vet Lab to obtain blood samples for some of that research work into badger vaccines. This work was to identify appropriate protective antigens to produce reagents for analysing the badger immune system.[85] It was an interesting project but at the same time we were doing other field investigations comparing different badger control programmes and using a blood test to see what was most effective.[86]

Stuart: Relevant to the RTA survey and, yes, I did all the bacteriology and a lot of the post mortems when I was in Weybridge. It was very interesting but I agree with Keith, you can't just keep funding something – it wasn't a proper stratified trial or survey, that was the weakness of it. It was interesting because we actually found TB in badgers in something like 15 different counties; they showed it was widespread even at that time. The diagnostic test in that case was post mortem and culture of a huge range of tissues. That's the most specific diagnostic test and it was very expensive and time-consuming. That's the other thing when you're comparing levels of TB, you must take note of which diagnostic tests have been used, and post mortem and culture is the most specific. You need to take note of the relative specificity and sensitivity of different diagnostic tests.

I was going to move on to how research strategies and funding are organized. Some of it is down to politics and I suppose we'll get onto that later. When I came back from Zimbabwe in 1999, the Krebs Report had just been published, and we got huge funding to set up a new TB research programme. I was very privileged to be able to be involved right from the start in that. The key to that was that we had a huge amount of money and it was right up there in the public perception because of the Krebs review.[87] Also by then, we had got

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[85] See, for example, Newell and Hewinson (1995).

[86] Mr Keith Meldrum added: 'This ran from 1994 until autumn 1996 but should have continued for 5 years. It was suspended until the results of the Krebs enquiry were known.' Email to Ms Caroline Overy, 13 April 2015.

[87] An independent scientific review chaired by Professor John Krebs was set up 'to review the incidence of tuberculosis in cattle and badgers and assess the scientific evidence of links between them; to take account of EU policies on reducing and eliminating the incidence of tuberculosis in cattle; to take account of any risk to the human population; and accordingly to review, in the light of the scientific evidence, present Government policy on badgers and tuberculosis and to make recommendation.' (Independent Scientific Review Group (1997), page 10).

on top of BSE and that was obviously going right down. So you just have to be in the right place at the right time, and politically it was the right time to have a lot of money put into TB. I wasn't at Weybridge in 1993, Keith, I was in Zimbabwe, but I was there in 1983, which was when we were looking at vaccinating badgers for the first time and we were actually developing TB challenge models in captive badgers for the first time then.[88] We did quite a few years of work on TB vaccination of badgers with BCG in the 1980s, and that again sort of fizzled out at the end of the 1980s, largely due to BSE and lack of funding. I actually left CVL in 1989 as well, although I don't suppose that was a huge factor in it.

Meldrum: You weren't supposed to leave!

Thomasin-Foster: Keith, you probably remember the panel was pretty upset at the loss of the badger road traffic accident data and indeed it was very important evidence as I remember for the mini panel we had where, of course, justification was sought for a removal operation. One of the things that always slightly worried me and I've never tried to think it through, is that, with an estimated 40,000 badgers killed on the roads each year, I just wonder whether there is a general perturbation effect from this slaughter. Okay, we talk about perturbation where there's been a removal operation, but it seems to me that perhaps there is a general perturbation caused by road traffic accident, the killing of badgers on roads (although there is not a lot we can do about it), but whether in general we have badger social groups continually disrupted and that is adding to the problems?

McGlone: Just a small piece of information that I've not seen referred to: there was some private funding that went into a vaccination programme in the early 1980s, an organization called the Silverwood Trust, which was funded by two individuals who then owned the *Hare and Hounds Hotel* in Gloucestershire. They put money in and I cannot, I'm afraid, today remember the names of the two people concerned, nor of the professor they retained to do the work. That was early 1980s – I don't know where it went.

Stuart: That does ring a vague bell with me but the professor that you are referring to is probably John Stanford.[89] He was at UCH and so I worked with him because all the badger work was done at Weybridge and I was the person

[88] Stuart *et al.* (1988).

[89] John Stanford is Emeritus Professor of Medical Microbiology at UCL and founder of Immodulon Therapeutics Ltd.

who did it. So he was very keen on trying *Mycobacterium vaccae* as a potential vaccine and it was a bit of a hobby horse of his and loads of work was done on it.[90] It's an environmental mycobacterium and his theory was that it could boost the immune system of badgers against other mycobacteria – in other words the pathogenic ones – but actually it seemed to have the opposite effect. There are immunological explanations for that. It was tried in humans as well with the same sort of effect.[91] So it was abandoned in the 1990s. It was actually discredited in the end but it took many years to reach that conclusion.

Williams: Just going back to the point somebody made about the road casualties and perturbation, it's never really been quantified but it could happen. There's also a natural progression where badger clans obviously get too big and some move away and get killed on roads. That's never been quantified either. It's very hard to know, when you pick up a road casualty, where it came from, how far it's travelled. There's no way of tracking it back to a certain, individual badger clan.

Clark: The peaks of the road casualties though are very distinct. Autumn and spring, when tension between adult males or sows 'push out' individuals from a colony to seek other territories, see more run over as a result. But most of my skins tended to date from January, February, and March, not much in the summer. Then casualties would pick up again in October and November, giving a peak with the autumn movements. These observations came out of keeping a diary and skins!

Montague: No one's actually referred to it but as part of the RBCT there was quite a detailed road traffic accident survey of badgers in seven counties: five counties that contained badger trial culling areas and two which were considered to be low-incidence counties as controls.[92] At that time, from about 2002 through to about 2005, I think we had something like 5,000 road traffic

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[90] See, for example, Stuart *et al.* (1988).

[91] For studies in TB in humans see, for example, Stanford *et al.* (1990).

[92] The RTA survey was carried out in Cornwall, Devon, Gloucestershire, Herefordshire, and Worcestershire. Shropshire and Dorset were used as controls. Mr John Montague added: ' … RTA badgers showed average prevalence of around 14% which was similar to the trial data for triplets within those counties and the ISG drew conclusions on the value of such road casualty surveys.' Email to Ms Caroline Overy, 24 March 2015. For a summary see Independent Scientific Group for Control of Cattle TB (2007), pages 75–6; for the statistical analysis, see ISG paper 1607 'RTA Prevalence analysis 2002–2005', available online at http://webarchive.nationalarchives.gov.uk/20061209155500/http://www.defra.gov.uk/animalh/tb/isg/publications/isg1607.pdf (accessed 11 May 2015).

accident badgers from the seven counties, but we also, for a year, picked up every mammal off the road and then, having reviewed that, focused on a small range of non-badger mammals for the subsequent two years, just to see what kind of level of reservoir infection there may be in other wildlife species. That was done under the auspices of the Independent Scientific Group on Bovine TB (ISG), chaired by Professor John Bourne who designed and analysed the RBCT, being able then to link those infections that they found geographically with the prevalence of badgers and the DNA strain typing of badgers in those particular areas. The relevance was therefore what information does it give you and does it give you enough information at the small scale level to allow you to take an intervention? And the ISG conclusion was that it didn't, apart from perhaps enhancing surveillance of cattle in an area where currently there isn't any spill over into cattle or perhaps, thinking ahead, the use of the vaccines in badgers potentially in clean areas.[93] In Mark's time, of course, it did support cases going to the mini panel for the approval of interim strategy Dunnet Type II removal operations.[94]

Meyer: On the RTAs, I know certainly in Cornwall, some illegally killed badgers were dumped on the roads to appear as RTAs and I wonder if, Michael, you saw any evidence of this in your carcasses.

Clark: Too early I think for that problem. Just a quick comment on the other animals: I did raise a bit of a hare at a panel meeting by saying: 'What about ferreters?' Because they take their ferrets all over the place and put them down holes, the ferrets often escape and get left in the wild. The question was, do ferrets carry bTB? There was some interest because the activity was scattered and unplanned, so it seemed to be another option. It brought up discussions on all the different animals that do suffer from bTB.

Thomasin-Foster: Just looking at the figures on ferrets from 1997 to 2005, it's zero.[95]

Meldrum: How about deer? When I was working in MAFF as it was then, we did have occasional cases, mainly in park deer and a few in wild deer. I just don't know what the situation is now. I certainly used to keep a note of all the

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[93] See Goodchild (2006).

[94] For Type II removal operations, see the discussion on the Dunnet review on pages 60–1 and note 134.

[95] See Appendix 1 for incidents of *M. bovis* infection in non-bovine domestic animals and wild deer in Great Britain confirmed by laboratory culture.

areas where we had them. We had them in Stratford-upon-Avon and we had them in the Purbecks and also in imported animals, I remember, but are deer a major problem at the moment? I don't know.

Montague: I'll answer it from my perspective but Fiona might have the scientific background for this. The situation with deer is that it's quite clear that under certain circumstances they are involved in the epidemiology and spread to cattle, but again, and it hasn't actually already come up, that I did say at one stage, we really don't know the actual method of transmission of this disease and the particular risk factors at the individual animal level. I think you see this very much in deer where it would appear in the grazing types of deer, especially fallow deer, fallow herds in the Cotswolds. Part of that ISG work involved selectively assessing fallow deer infectivity in three zones in the Cotswolds. This did show a fairly high level in fallow, where fallow are coming into contact with grazing cattle.[96] Of course, deer are a potent epidemiological species in New Zealand as a potential transmission risk. In all those cases the prevalence in deer was lower than the background prevalence in badgers in those particular counties. Where you're dealing with solitary browsing deer, the roes, the woodland deer, they probably aren't involved in the epidemiology, but the herds of grazing deer may be. It is suggested that perhaps in the Cotswolds they do have a role in the epidemiology but, of course, they can be controlled. Also the red deer herd on Exmoor definitely has been involved in epidemiological spread in the Dulverton area, often associated with the artificial feeding of the deer at the League Against Cruel Sports place in Dulverton, by harbouring deer, bringing them off the hills to artificially feed them and protect them from hunts. There's been infectivity in the deer population there.[97] Muntjac have shown quite a high level of infection, but the sample size is very small and really they are pretty solitary in woodland, and I don't think would pose too much of an epidemiological risk for cattle. That's about as much as I know, and that was up to two and a half years ago when I left Defra so I don't know really what the situation is now.

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[96] Samples were taken from deer in three adjacent areas in the Cotswolds: West Cirencester (Cirencester Park), Chedworth, and Barnsley Wold; results showed the percentage of *M. bovis* infection to be 8.1, 15.9, and 0.0, respectively (Paterson (2008)).

[97] Baronsdown, near Dulverton, Somerset, is 200 acres of land acquired by the League Against Cruel Sports in the 1960s and is a sanctuary for red deer. In 2008, a report commissioned by the Exmoor National Park Authority showed that between 2000 and 2008, there were 84 confirmed TB cases in red deer around Exmoor, 76 of which were from the vicinity of Baronsdown (Werrett and Green (2008)).

Stuart: Yes, I did quite a lot of work on TB in deer in the 1980s and it had already been shown in several species of wild deer; I think Archie McDiarmid was one of the original people who found it.[98] Actually, what I was involved in was the first outbreak of bovine TB in farmed deer and they were imported from Hungary, and we had several really severe outbreaks in Sussex and various other places, but mainly in the South East.[99] There was a very high prevalence but, as John has alluded to, that was because they were farmed in very high density and kept as farmed animals. I think deer are very susceptible to TB, particularly red deer.

Meldrum: Fiona, when did you have those problems in deer, I can't remember?

Stuart: It was 1985.

Meldrum: Was there any thought that they could be associated with badgers, or was it thought to be cattle-to-deer transmission?

Stuart: What, the farmed deer, do you mean?

Meldrum: I remember the cases from Hungary, yes, but there were other odd outbreaks that occurred, some of it in park deer, I seem to recollect.

Stuart: There was an outbreak in park deer.

Meldrum: One in Stratford, one in Staffordshire. They kept popping up and I don't think we knew at the time what the source of infection was.[100]

Stuart: I think some of them were associated with cattle TB – I can't really remember – although they would be sporadic, low-grade outbreaks, if you like. The ones that I studied in quite a lot of depth were definitely with imported red deer from Eastern Europe. It just went through the herds like wildfire and in fact they had to depopulate. They tried to control it but they had to depopulate completely in the end, they couldn't control it. It just really shows that deer are very susceptible, particularly red deer, and it is a big problem in New Zealand where I also worked for a year in 2004. As John has

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[98] Matthews, McDiarmid and Collins (1981). See note 13.

[99] Stuart, Manser and McIntosh (1988).

[100] Mr Keith Meldrum added: 'A number of confirmed outbreaks in wild, captive, and farmed deer were reported in the CVO's annual reports between 1990 and 1997. In some cases the origin remained obscure whilst others were associated with outbreaks in cattle or with imported deer.' Email to Ms Caroline Overy, 13 April 2015.

said, they've got feral deer there, they're not native wildlife. It is a real problem and, of course, they can't control them because they are now, to all intents and purposes, wild.[101]

Montague: Can I just add to that? I can't specifically answer your point, Keith, on all the park deer. The moment you have TB in a park it's very difficult to control because they're not handleable and all you can do is restrict the herd, look at all the culls and post mortem data, and decide at some point that infection may have been eliminated or cull the whole lot. We have had park deer infected in those parts of the country where there's a background reservoir in badgers. Also we have had park deer infected in Ulverston in Cumbria, for instance, where there wasn't, at that stage, a known TB problem in cattle or badgers. There were all the rumblings because of the foot and mouth restocking in Cumbria, there may have been some wildlife infection. The picture in the early 2000s wasn't particularly clear. So that's the deer. But deer are regulated, they are under statutory order and you may argue that in fact they are over regulated for the risks now that they pose. They were regulated in the late 1980s on the back of the problem that was evolving in the newly developing farm deer industry where they imported disease from Hungary. You may start to think why were deer infected? How did they become infected? And now look at why we're getting infection in outdoor pigs, why we're getting infection in sheep? Why didn't sheep, which have been grazing the same pastures as cattle for decades, become infected for a long period and are now occasionally becoming infected?[102] I might suggest to you that it's something to do with the different behaviour of cattle and sheep and the grazing environment, if they are exposed to the same risks from a wildlife reservoir. Of course, you've got the New World camelids, the llamas and the alpacas.[103] The alpacas are frighteningly diseased when they are infected and die very quickly and there's not much of a diagnostic test. My question I would throw out is how does an alpaca or a llama behave in the grazing environment to either contamination

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[101] For the problem of the presence of *Mycobacterium bovis* in deer in New Zealand see, for example, Nugent, Gortazar and Knowles (2014), and for the management and eradication strategy, see for example, Hutchings, Hancox and Livingstone (2013).

[102] For a case of TB in a flock of sheep see, for example, van der Burgt *et al.* (2013).

[103] For a discussion of *Mycobacterium bovis* infections in domestic species see, for example, Broughan *et al.* (2013a and b). See Appendix 1 for incidents of *M. bovis* infection in non-bovine domestic animals and wild deer in Great Britain confirmed by laboratory culture from 1997 to 2011.

from wildlife or the presence of a wildlife species, compared with a sheep that may be on the same grazing environment? Is it behaviour that puts them at risk or are they genetically more susceptible? These are the questions we don't really understand between species and even within species because cattle farmers will consistently say TB is in a line of cows, or it's the bossy cows, or the pet cows. Now is that genetic? I think there could be some basis for a genetic risk, but I think a lot of it is behaviour and who is the boss cow that investigates the badger in the grazing environment? I think in Keith's time there was probably too much emphasis placed on indirect transmission risks, the oft-quoted 300,000 organisms per gram or ml of badger urine,[104] but I really think it is the risks of badgers and domestic animals coming into relatively close proximity that is transmitting the disease.

Williams: This just leads me on to ask: routes of transmission have been mentioned but you people who've worked in the industry, how much research has been done into the route of transmission and how near are we, or are we miles away, from finding a route of transmission either way, badger to cattle, cattle to badger, cattle to deer or any other mammal?

Meldrum: I must come back, John, on the last comment you made. When I was advised about TB controls in badgers we were not looking at the number of organisms per gram, we got that wrong big time with BSE as to how much infectivity there was in cattle brain, but not on this, not on TB. We always assumed, and that was going back to West Penwith, that this was direct contact – cattle to cattle in the main, and then cattle to badgers and badgers to cattle. I'll come back to that later because it's a very contentious issue but we were not looking at infective doses and so forth. We were assuming that there was contact between cattle and cattle, a major source of transmission, and from time to time cattle into badgers and then back from badgers into cattle. I was not looking at dosage and doing the risk assessment on that basis. Sorry, that is not how you can do the sort of medicine I was involved with. When you have to make policy decisions, or give policy advice, at the end of the day you've got to come down one way or the other. You can be wrong, you can be right. I will say on BSE we got some major decisions totally and completely right thanks to John Wilesmith, but on other areas you've got to take a view. You receive the advice from a lot of people who know a lot more about TB than I did and then on that basis you had to come to a conclusion and decide

[104] See the MAFF Report *Bovine Tuberculosis in Badgers* (1976), Appendix 6, online at www.bovinetb.info/docs/bovine-tuberculosis-in-badgers-maff-nov-1976.pdf (accessed 5 May 2015).

in which direction you go. It's quite a lonely task and, yes, I understand that you were unhappy about the roadside casualties, but we made one or two decisions that weren't popular.

Montague: I wasn't disputing the cattle-to-cattle transmission risk, it was looking at badger-to-cattle transmission or cattle-to-badger transmission. In that, and I don't think we understand, but my feeling is that it is probably through direct, relatively close aerosol exchange, rather than exposure to a contaminated environment or contaminated feed. That was my emphasis in the dynamic cycle of infection moving from cattle out of the species into wildlife and from wildlife back into cattle: is the emphasis on a contaminated environment – cattle smelling urine, dung, or consuming infected feed? Or is it actually cattle coming into relatively close proximity with an infected wildlife either in the grazing or in the housed environment, because we know that badgers will make use of the housing resources? So I wasn't disputing the risks, it was merely the 'keeping badgers and cattle apart' MAFF publication did focus a little bit on the indirect transmission risk, which I supported at the time but I think my feeling with more recent work is in maybe more direct transmission. I think we were told for a long time that badgers and cattle don't interact in the grazing environment and I think they do.

Thomasin-Foster: There was a fascinating piece of work done by Professor Stephen Harris looking at the urine trails given by badgers going through fences and onto pasture,[105] often onto pasture for worming, particularly perhaps after silage had been taken, when worming for badgers was considerably easier. These urine trails were laid by badgers on the field edges, and then when young stock were let out onto that cut pasture many cattle would have gone to graze the very edge of the field with lush grass, which hadn't been cut for silage because of the impracticality of the machinery working very close to a fence line. This is the sort of thing I was meaning earlier on, when I mentioned that farming practices seem to have potentially quite a significant impact of the chances of disease transmission.

Macdonald: A couple of quick things. On the business of transmission and indeed the urine marking and other sorts of scent marking, which is probably very relevant, we had a meeting a few months ago and I forget

[105] White, Brown and Harris (1993); Hutchings, Service and Harris (2001); Scantlebury *et al.* (2004).

under whose auspices, but it was held at the Royal Society, looking at what were still the surprising unknowns, and I remember two salient points came out of that. One of them was that there are all sorts of candidate mechanisms for transmission, as people have just been discussing, but actually the main routes of transmission remain unknown, which is a pretty central thing to still be a bit puzzled about. The other thing that came up, which might be interesting to follow up, is that there's so much talk, and well-meant talk, about mitigation and ways of intervening to alter agricultural practice in terms that might diminish contact rate. But actually when you drill down to it nobody's got any very clever ideas of what that might be.[106] It's a bit in the sort of 'motherhood and apple pie' category and so I think that's a really rich vein to be explored: what could be done in terms of management? I remember a piece of work Fiona Mathews and I did looking at the breakdown rate on farms depending on things like field size and hedgerow density and we came up with some speculations about how hedgerows might affect the movements of badgers, and might in turn affect contact with cattle.[107] The fact is that there were such relationships between land management practices and transmission rate at the end of the day.

If I might go on for a moment more on a different topic, it occurs to me that another strategic thing that those of us who have done this for a hundred years now can start to take a perspective on, is the quest for the impartial expert. I imagine this comes up in a lot of parts of science but if you think about it, those of us whose teeth are getting longer, the fact is that there's been a whole succession of organizations, formal and informal. There was the Badger Panel, we've heard a bit about; and then John Krebs and a cluster of people around him and an independent panel; and then there was another cluster of august scientists around that; and then each successive government tries desperately to find some new set of people that can apparently offer a fresh opinion. It comes to mind that Tim Roper had an expert group once;[108]

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[106] In April 2013, 50 scientists involved in bovine TB and wildlife research met at the Royal Society in April 2013 to discuss Government's approach to tackling bovine TB (Defra (2013)).

[107] Mathews *et al.* (2006). Dr Fiona Mathews is Senior Lecturer in Mammalian Biology and Programme Director for Biosciences and Animal Behaviour at the University of Exeter.

[108] Professor Timothy Roper is Emeritus Professor (Evolution, Behaviour and Environment) at the University of Sussex. His research focused on animal behaviour and ecology, including the transmission of bovine TB between badgers and cattle.

Charles Godfray, twice;[109] Mark Woolhouse, now in Edinburgh, once;[110] there's a sort of quest. The cynic might look at these sometimes and say: 'Well, of course, it's a wonderful thing to get a fresh perspective.' But there certainly seems to me, over the years from the biology part of this, to have been a really pretty strong convergence of views so most of the people who actually have anything firsthand to say about this say roughly the same thing nowadays. There's a bit of a quest to see if you can just find somebody who will take a different perspective and, of course, one could imagine politically that could sometimes be the desire. But the fact of the matter is, there's nobody left in this country, who knows anything about it, who has not been on some sort of expert panel and so the quest for independent expertise has become a sort of merry-go-round really.

Stuart: I'll just address that last point from David. When I came back to MAFF, then Defra, in 1999, I was involved in setting up most of those groups that he's just alluded to. The trouble is that it would be great if we could find sensible, new people who could suddenly say: 'Hurray, we've got all these brilliant ideas', but you do need people who know about the subject and it is actually quite a small group. We'd be racking our brains to try and think of new people, and actually Charles Godfray was one of them because he wasn't actually involved in TB at all and he got handed the poisoned chalice really, chairing a group looking into the reactive culling, after it had been stopped.[111] That's some more recent history, but it's very difficult to find good experts who aren't partisan, it's almost impossible. Going back to the other point about what was the infectious dose and the route: well, experimentally the infectious dose for TB is very, very small. I mean you can establish infection with five colony-forming units, which means five organisms. You can probably do it with one, but, what does that mean? That's in an experimental situation, intra-tracheally. How one actually proves

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[109] Charles Godfray chaired the Independent Scientific Review of the Randomised Badger Culling Trial and Associated Epidemiological Research, which was set up to review the progress of the RBCT (Godfray *et al.* 2004).

[110] Mark Woolhouse is Professor of Infectious Disease Epidemiology at the University of Edinburgh.

[111] Godfray *et al.* (2004). Reactive culling (culling locally near farms with outbreaks of TB) was suspended in November 2003 because the incidence of TB in cattle showed an increase of nearly 20 per cent in those areas due to the perturbation effect. For further comments on the reactive culling see the discussion between Mr John Montague and Professor David Macdonald on pages 53–5.

what happens in the field and which route is more important, I don't know how you could design a proper experiment to test that. I believe, personally, that there are several routes by which mammals, including humans, can become infected. It's been shown in humans, we know that you can get orally infected, but it's primarily a respiratory disease and I think the same is true in cattle and badgers. It is primarily a respiratory disease and we see the evidence for that in the pathology at post mortem. But how you can show that experimentally is very, very hard to think of a good experiment. There are other routes as well but they are less important.

Meldrum: I'll just come back to this interesting comment about independence. I understand totally what you're saying. I'll make a cheeky comment; I'll be careful what I say, though. If you look at the Krebs Committee there is a bias and I got caught in a trap on that bias because there are three people on that group who are part of what I would call the 'Oxford Group', i.e. they were at one time, or had had very close connections with, the Department of Zoology at the University of Oxford, although they've moved on thereafter, and it worried me hugely. I got caught in a trap because John Krebs was appointed to lead a committee, and he then selected who he wanted on the committee.[112] I won't go into more detail than that but I would have preferred to have had a wider representation on that committee, which was outside the Krebs Group. Because Krebs was a very powerful, is a very powerful, guy and a lot of scientists had worked with him. But this all came to me during, once again, BSE and who is independent? I get quite fazed about this: when you hear on television/radio, 'this independent scientist is giving a view', you ask a question: 'How can a scientist be totally independent because he must

[112] The Committee comprised Professor John Krebs, Chairman (Chief Executive of the Natural Environment Research Council and Royal Society Research Professor in the Department of Zoology, University of Oxford); Professor Roy Anderson (Director of the Wellcome Trust Centre for the Epidemiology of Infectious Disease and Linacre Professor and Head of the Department of Zoology at the University of Oxford); Professor Tim Clutton-Brock (Professor of Animal Ecology at the University of Cambridge); Professor Ivan Morrison (Head of the Division of Immunology and Pathology at the Compton Laboratory of the Institute for Animal Health); Professor Douglas Young (Fleming Professor of Medical Microbiology at Imperial College School of Medicine); Dr Christl Donnelly (Research Statistician at the Wellcome Trust Centre for the Epidemiology of Infectious Disease at the University of Oxford). They were assisted by Dr Simon Frost (Department of Zoology at the University of Oxford) and Dr Rosie Woodroffe (Research Fellow at the Department of Zoology, University of Cambridge); (Independent Scientific Review Group (1997)). See also further comments on pages 76–7.

rely upon funding from somewhere?' Wellcome's a problem, because many excellent scientists are Wellcome-funded or they receive financing, big finance in the case of BSE or CJD, from the Wellcome Trust, and they want that money to continue in the future. Therefore they want to publish and I still think that some of the publications on CJD were a bit dubious at the edges. In fact, we haven't made much progress on some of the work that in 1996 was thought to be so groundbreaking.[113] However, the issue of independence is quite difficult. To those here today, I would say to you: 'Well, are you totally independent?' Because most of us are not. Our background is relevant, where we come from, be that in government or outside. In fact, in the main, government civil servants in research laboratories are pretty independent because they are not worried about their job and they're not so worried about their funding. I had great reliance upon them and put great reliance on the advice that came from our government scientists and from other government and government-funded laboratories.

Macdonald: Just to quarry a tiny little bit further into this, in case it is interesting in terms of the history of how science unfolds. I think there are two points that Keith, Fiona, and I are touching on here, and I just want to be clear that they're recorded as separate. One of them is the 'running out of experts' phenomenon – you use them all up and they're gone. By the way, talking about independence, I wasn't impugning for a moment anybody's not playing with a straight bat, that wasn't my point. It's just that, as Fiona said, you run out of new voices. And, of course, as Keith says, there's a lot of genealogy going on here – Rosie Woodroffe, who I've mentioned a few times, she did her undergraduate thesis and her DPhil, under my supervision, on perturbation. So one can see all these people are related. I worked with John Krebs most of my working life. But I don't think that impugns anybody's independence, it's just that we all come from stables of one sort or another.

There is a different point, which I partly had in mind, about representativeness and reporting. One thinks of the famous tortured case of the *Today* programme trying to be even-handed about climate change and choosing one person to speak from the 5,000 or so climate scientists who realise that climate change is happening, and one person to speak from the one scientist lobby who doesn't think it's happening. And you get one to one, but you see the point I'm drawing there. I think that part of the quest for new voices, which I think is

[113] See, for example, Will *et al.* (1996).

interesting, and this surfaced very much in the recent quest to get alternative opinions on the rolling out of the Gloucestershire and Somerset trials that have just been done now.[114] I would say, if it's not too recent history, that has not been handled terribly well, and does not deal with evidence, with the quality of thought that defines some of the earlier interactions. I think there was a quest to find anybody who could put a contrarian view even if that was a terribly minor one. Is there anybody left in this country who knows anything about TB who does not think the perturbation effect is relevant?

McGlone: Just to pick up on that, that does also have an impact on civil society and I know of three inquiries at various stages, where there was a struggle to try and find someone to chair who had credibility and who had knowledge. In each case there was no successful outcome because the names that were bandied about, there was then the: 'Well, they would be regarded as having a position, wouldn't they?' It does have an effect because the subject is complex and it's not a case of just having a fine line to be able to take this forward. It's actually having the perspective and understanding as well to make sense of some of the issues.

Stuart: Just following on from what Keith and David were saying. I keep harping on about when I came back in 1999 because I know the date as I came back to this country after having not worked in TB for ten years. One of the big changes was, because of the BSE report, there was just a huge move within MAFF, as it was then, that everything had to be absolutely squeaky clean, independently peer-reviewed, and we put such a lot of effort into getting really good peer-review done on the new research programme on TB that I was involved in – actually on all the animal health and welfare research programmes that I was also involved in to some extent as well. That was a really positive outcome from the BSE saga really, and that still continues now within all government-funded research programmes in animal health. I'm sure it's applicable to other areas as well, that a huge effort is made to get peer-reviewers from a range of disciplines and a range of backgrounds – academia, industry, government, international as well, not just from this country. So I

[114] In 2013, culls supported by Defra and the National Farmers Union (NFU) were carried out in Gloucestershire and Somerset as part of a pilot project to reduce bovine TB. See the government reports for this cull online at www.gov.uk/government/publications/2010-to-2015-government-policy-bovine-tuberculosis-bovine-tb/2010-to-2015-government-policy-bovine-tuberculosis-bovine-tb#appendix-4--controlling-bovine-tuberculosis-in-badgers (accessed 13 May 2015).

think we can be assured that actually a massive amount of effort is put in to try and get the best people, and also in setting up these various panels that we've been talking about.

Montague: As there seems to be a bit of a baring of the soul, David, I'm fully persuaded of perturbation. As a concept it strikes me as eminently realistic in a socially organized wildlife population that defends its territorial boundaries. Can I say though from the coalface of someone who was actually charged with implementing the badger culling trial, many of the design features seemed to be driving to come to an observation or a conclusion on perturbation rather than trying to see what the impact of badger culling would do on cattle TB, which I found frustrating. I don't accept your belief in the reactive trial result; you're quite clear that at the time I absented from that view.[115] It's quite clear that before any culling took place the level of disease in the reactive areas was increasing relative to the control areas, so you appear to have a mismatch between reactive and control. Prior to the publication of the *Nature* paper in November 2003, some members of the ISG did acknowledge that what was measured was the effect of being declared a reactive area rather than the effect of reactive culling itself.[116] It was quite clear that, at the time of publishing, it really was an inaccurate paper.[117] I don't think the reactive result tells us anything but what the proactive result tells us is that perturbation is a fully logical concept and then history was rewritten and the ISG used the proactive result to say: 'Well, the reactive probably said the same thing.' I don't think the reactive result supports that in any way at all, because the majority of

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[115] Mr John Montague wrote: 'The Defra Chief Scientific Adviser at the time convened a meeting of the good and the great probably in 2004/05. In the minutes of that meeting it is noted that the National Trial Manager (me) did not agree with the consensus of the meeting that the reactive trial result was due to perturbation.' Email to Ms Caroline Overy, 24 March 2015.

[116] Mr John Montague wrote: 'This was in a very heated meeting of the ISG (they had regular monthly meetings with officials – totalling around 100 in all) on the afternoon of the first ISG open meeting that had taken place that morning – probably the first week in November 2003. At this meeting, we as officials were drawing our concerns with their draft *Nature* paper to the attention of the ISG in an attempt to stop publication. It was clear that incidence in reactive areas was rising before any reactive culling took place compared with the control areas but the data analysis started from when the triplet went live (following the conclusion of the first proactive cull). Due to resource and FMD (foot and mouth disease) delays it was often quite some time before any reactive culling took place. It was the view of several of us in Defra that it was absurd to consider measuring any differences in incidence rate before any actual culling had occurred.' Email to Ms Caroline Overy, 24 March 2015.

[117] Donnelly *et al.* (2003).

badgers were actually killed in the last few months before the analysis was done. When you're dealing with a surveillance cycle in cattle of one year and a necessity for cattle to become infected, there was no way that the culling that took place at the end of that reactive period could have impacted on those results at all. We had a very, very, very difficult discussion with the ISG in 2003 and in my view the paper shouldn't have been published.

Macdonald: Okay, a couple of points on the soul baring. The first is, John, that I don't think there's probably the width of a cigarette paper between us in our appreciation of the strengths and weaknesses of perturbation. It's a pretty obvious idea, it just happened that it fell into my life at the moment when this was all unfolding and I gave it the name. So it's not a matter of religious conviction for me, although there is significant evidence in many cases around the world, mainly to do with mammals, of a perturbation effect in its generality affecting wildlife management. The one I work on most at the moment is the impact of trophy hunting for lions on the sociology of lions.[118] So it's a general concept and it's so unsurprising that one could scarcely argue it away. I think that regarding the RBCT analyses and those that have flowed and continue to flow much more recently, that my encapsulation of it is that we can see in the data, facts on the breakdown of cases of cattle in the core and peripheral areas, which are commensurate with a perturbation explanation. So far there isn't a better explanation and the accumulation of various different snippets of evidence, all of which are commensurate with perturbation, makes it increasingly easy to think that maybe that is the mechanism that's at work. Maybe there's another nobody has thought of yet. Certainly something is at work to mean that a simple contact rate model, Kendal threshold coefficient sort of model of disease transmission and reducing populations, isn't working in badgers, and perturbation seems to have a strong support there.[119] So I'm not proselytizing for it, I just think it matches up. Regarding the reactive stuff, my feeling, and this is not my work by the way, is that things have unfolded very interestingly recently and I would say, exactly as John said, there was a sort of shotgun wedding type of impulse to stop the reactive trials and work was published and it probably was premature and maybe unfounded. What I think is very interesting is that there are two other strands of evidence that suggest, maybe even by chance, the right decision was made even if not for

[118] For papers on the sociology of lions see Macdonald and Loveridge (eds) (2010).

[119] The Kendall rank correlation coefficient, or Kendall's tau (τ) coefficient, measures the association between two measured quantities.

the right reasons. One is that our own work within the RBCT, at the Triplet E sites they were called lovingly, looking at the behaviour of individual badgers in the face of the attempted control, did suggest that their behaviour changed in a way that was commensurate with a perturbation idea and therefore there was some more evidence for it.[120] More compellingly, Christl Donnelly, whom we mentioned earlier – together with a very good Postdoc called Flavie Vial who, thinking of genealogy, trained under me in Ethiopia in Ethiopian wolves, so everybody is sort of linked to everybody else again – has published a couple of very mathematical papers in the last year, if I remember rightly, looking with hindsight at the reactive zones and concluding that there is, or was, a perturbation effect with a run of analyses that couldn't have been done at the time.[121] Now I didn't do those analyses and they're mathematically very intricate so I could scarcely comment on them, but I think while you might have been right to be sceptical of the judgement at the time, it appears as if it's now retrospectively being supported but I couldn't comment on them.

Meldrum: I just want to comment upon Fiona's remark about peer-reviewed research. I want to make the point, for the record, that having been involved in the BSE Inquiry for two and a half years of my retirement, there was no recommendation and no criticism of MAFF in the way it conducted the experiments on BSE, none whatsoever. We had in-house a peer-review system insofar as we had a very eminent Spongiform Encephalopathy Advisory Committee and all the major research projects went before them. We didn't publish one particular study in hounds because the results were so odd. But apart from that there were no criticisms from the Inquiry on the research that we did.[122]

Stuart: Just to clarify: I wasn't suggesting that at all because obviously I knew what was happening, at Weybridge anyway. It was just a recommendation coming out of the BSE Inquiry, wasn't it Keith, that independent peer-review should be done as much as possible? There was some recommendation written as a result of the BSE Inquiry.

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[120] The Triplet E Experiment in Wiltshire between 2000 and 2004 was a RBCT trial to compare a badger population subjected to culling with a control population. See Macdonald, Riordan and Mathews (2006).

[121] Dr Flavie Vial is a postdoctoral research assistant at the Veterinary Public Health Institute at the University of Bern, Switzerland. See Vial and Donnelly (2012); Vial, Johnston and Donnelly (2011).

[122] The BSE Inquiry report was published in October 2000 (Phillips, Bridgeman and Ferguson-Smith (2000)). It is available online at http://webarchive.nationalarchives.gov.uk/20060715141954/http://bseinquiry.gov.uk/report/index.htm (accessed 22 December 2014). See note 84.

Grant: We have strayed into the recent past quite a bit, which is understandable, but we are meant to be focusing on the period up to the Krebs study. I think I'd like to go back a bit in time: Thornbury was something that was mentioned that might be worth looking at again, but I'd also like to consider the events leading up to the Zuckerman Report and the consequences of that. Then, of course, the Dunnet review and the Badger Panel after that. I think it would be a good idea if we could focus more tightly on that period.

Thomasin-Foster: It was me who mentioned Thornbury, which I think I'm right in suggesting was at the end of the 1970s but I would have to say that I'm a little bit hazy about this.[123] The sort of information that I can remember was that it was heavily gassed, repeatedly gassed, but what I don't know was what the cattle movement situation was in Thornbury, it was quite a big area. I would have thought perhaps that might be something that could be thought about. If I'm right, Keith, someone will tell me, it was some 20 years before we had a breakdown back in Thornbury but I may be wrong on that. But to me that was a pseudo experiment, which might just lead a little bit more to conversation at this stage.

Meldrum: I didn't come really into play in this area until about 1986 when I was Director of the Veterinary Field Service, so prior to that time I was working basically in the field in the Midlands. I got more involved with policy and even more so from 1988 onwards when I was CVO. As I recollect, I went out to Woodchester Park a couple of times and met the guys there, saw what they were doing, and their work was fascinating; for instance, how badgers were moving at night. But we didn't get the increase in tuberculosis in cattle in the Woodchester Park area that we expected and therefore to some extent the guys there were suggesting that the transmission of the disease from badgers, which were infected and were sampled routinely by the team that were in Woodchester Park, to cattle was quite difficult. But certainly I think that provided some very useful information on individual badgers, their infectivity when they were sampled, and also their movements because, of course, they were putting dye into peanuts that the badgers ate and they were tracking their movements overnight.[124] I think that was some very important work but I did not get involved in policy until 1986.

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[123] A badger clearance trial was set up in the parish of Thornbury, Avon, in 1975 and between then and 1981 all badgers in the 104-km^2 area were systematically killed. The results from this clearance, a decrease in the incidence of TB in cattle, supported the view that the removal of badgers decreased the risk of infection in cattle. See Clifton-Hadley *et al.* (1995).

[124] For the tracking of badgers see, for example, Delahay *et al.* (2000).

Grant: We had a reference to Zuckerman earlier in terms of him turning up with his chauffeur.[125]

Montague: I can't add very much on Thornbury apart from what I read as part of the historical background – the figure 104 km^2 stands out, bordered by the River Severn, the M4 and the M5 in Gloucestershire – repeatedly gassed from 1975 to, I don't know whether it was 1979 or it was to 1981 because you know gassing was suspended when Zuckerman was sitting.[126] I don't know whether they did a final round of gassing, David might know. I'm aware that Wilesmith and Clifton-Hadley have written it up that there was meant to have been a reduction in TB and no further incursions for a period of time; you said 20 years, I would have said 10 years but I haven't read the paper recently.[127] The difficulty for us working in policy post-Krebs was that Krebs assessed Thornbury and Steeple Leaze[128] and didn't think it could contribute to the evidence base on the basis that it wasn't a randomized controlled experiment and the reduction in TB could have been put down to chance. So it was quite difficult for us to raise it as a valid option, as well as gassing not really being on the table as we just didn't have any licensed gas. There may or may not in the future be a licensed gas and then one has to think how would you deploy that on a wide enough, contemporaneous basis to reduce or eliminate a perturbation risk?

Williams: I can't say I know too much about Thornbury but I have read somewhere, or I have heard somewhere, that there were no cattle movements during trials, but I don't know whether that's the case.

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[125] See page 24.

[126] Gassing with hydrogen cyanide was suspended between September 1979 and October 1980 during the Zuckerman review and was banned in 1982 following an investigation by Porton Down, which considered it inhumane.

[127] The conclusion of the paper was that: 'The analyses presented indicate that eradication of tuberculous badger populations from a defined area, where tuberculosis is known to occur in cattle, resolves the cattle problem for at least 10 years, if the action taken is thorough and steps are taken to prevent recolonization for several years. Up to the end of 1992 no culture-positive reactor cattle had been detected in the intervention area since control ceased, although recolonization by badgers has been possible for more than 12 years.' Clifton-Hadley *et al.* (1995), pages 191–2.

[128] Following a major outbreak of TB in cattle on a farm in Steeple Leaze, Dorset, badgers were totally removed from a 12-km^2-area by both trapping and gassing between 1974 and 1979; see Wilesmith *et al.* (1982); Little *et al.* (1982).

Macdonald: My recollection of Thornbury and Steeple Leaze – apart from the fact that, as John says, they were one-offs, and so in terms of scientific design it wasn't a design, but one-offs can still be indicative – is that, at least in the past, the feeling was that they were actually very successful but they involved killing seemingly large numbers of badgers over very large areas. My recollection, others will correct me if I've got this wrong, was that the main problem was that it was thought to be politically inconceivable that a decision would be made societally, or indeed even legally, to kill badgers over such large areas as part of rolling out a scheme. That's my recollection. So I think it was the large-scale killing that was thought to be societally unacceptable at that time.

Meldrum: I mentioned earlier that, of course, Ministers have a very important part to play in any government policy, particularly with tuberculosis and badgers. During my time as CVO (1988–1997), I worked for 15 or so Ministers and, I don't want to name names but we did have some real problems with the scientific evidence with one Minister. Submissions that we put up where we would recommend that something should happen, that we should try something out, that we should do something differently, which affected badgers in any way. Some of our Ministers were extremely sensitive to that. It was probably the one area in my time as CVO when I had a real problem when I could not persuade one ministerial team that something ought to be done, that we ought to think again, try something else, because at that time I was convinced that badgers had a major involvement. Part of the problem was obviously presentation, and politically it wasn't very comfortable for Ministers to make an announcement that we intended to do something to maybe curtail, control, or reduce badger numbers.

Whatever you intend to do with badgers, politically, is likely to be unacceptable but we had another major problem at the time, a fundamental problem that I had all the time that I was CVO, and that was that there was uncertainty about the role of badgers in transmitting disease to cattle. Because I remember from the earlier reports, and, Chairman, you mentioned just now, there was always uncertainty. Obviously badgers were infected, badgers had tuberculosis and it was reasonable to assume that some of those badgers picked up disease from cattle, but the question came up time and time again, at public meeting after public meeting: 'was the badger a source of infection for cattle?' During my time as CVO that was a major issue and therefore if Ministers had decided

to do something to control badgers in any way whatsoever they would have come up against this mammoth stumbling block that, in general, the welfare societies, those that were concerned with the protection of the badger, would not accept the available evidence. The evidence only suggested that the badger could be involved, and it wasn't surely until the Krebs Report came forward, that it was far more clear on the association between badgers and TB that maybe the whole discussion could move forward. That was a major problem for us, my team working in Tolworth, talking in public meetings and looking at the correspondence in the *Veterinary Record* and elsewhere. In the national press there was always criticism; we were told that we weren't doing enough to control cattle movements; we weren't doing enough to improve the sensitivity of the tuberculin test; we weren't putting enough money into tuberculin testing; farmers were not in fact doing what they could to try and reduce contact between badgers and cattle, and so forth. Maybe they were right. Certainly in the context of tuberculin testing, I think there was a major problem. I do not think that the standard of tuberculin testing carried out by veterinary surgeons was as high as I would have liked. That meant that during my time as CVO we put a proposal to the Royal College of Veterinary Surgeons that they should consider allowing lay people to carry out tuberculin testing of cattle. At that time lay persons were taking blood samples from cattle for brucellosis testing and from pigs as well and so forth, and that was roundly turned down by the Council of the Royal College of Veterinary Surgeons; they wouldn't touch it with a barge pole. But I took the view, and so did my senior team in Tolworth, that there could be some advantages in using lay people because they would be more diligent and accurate in the way they carried out tuberculin testing. So that was something where we failed to make an improvement that has now been put in place.[129] But certainly Ministers were very sensitive about badgers and any discussion we had with Ministers would touch upon whether or not there should be any controls. One Minister said: 'No, you will do nothing about badgers whatsoever! You will leave them untouched. No trials, no experiments, no nothing.' It wasn't until 1993, when Nicholas

[129] Following a consultation in 2003 on proposals to introduce legislation to permit suitably trained Animal Health Officers or lay staff of Local Veterinary Inspector (LVI) practices to carry out TB testing, the Veterinary Surgery (Testing for Tuberculosis in Bovines) Order 2005 came into force on 15 August 2005 to enable the Animal Health Agency (previously the State Veterinary Service) to carry out a pilot programme designed to evaluate the possibility of allowing TB testing by lay persons. The report of the pilot project run from 2005 to 2006 can be read online at http://webarchive.nationalarchives.gov.uk/20130402151656/http://archive.defra.gov.uk/foodfarm/policy/animalhealth/vservices/pdf/testpilot-report.pdf (accessed 23 December 2014).

Soames[130] was the Parliamentary Secretary with whom I worked very closely, that we introduced a new programme of research at the Central Vet Lab into badger vaccines. But it was a wider programme than that, it wasn't solely and simply on that. It was mainly trying to find a new vaccine that could be used in badgers. Unfortunately, no, they didn't find one but there was a very good team in place at that time with some very eminent people leading it, and with input from outside and some of whom we have mentioned today. So we were trying to do a lot but we were, to a large extent, hamstrung. It wasn't until Krebs came forward with his report that things, I think, moved forward a little bit.

Meyer: Regarding Thornbury, maybe I can shed some light on this. I have this text from the Wildlife Link 1984 Report,[131] I think, which went to Dunnet.[132] They said at Thornbury about 220 setts were gassed – this is from Zuckerman in 1980; and since recolonization began in May 1981 – this was MAFF 1982 evidence – 'only 10 badgers are thought to have recolonized the area. The badgers appear to be very mobile and although 14 of the previously gassed setts have been reopened none appears to have been reoccupied for more than a few days at a time' – that was from 1983.

Grant: I wonder if we could think a little bit about the significance or otherwise of both Zuckerman and Dunnet. You may not have been directly involved but what were you told about that, or what were your recollections about what people were thinking about those reports?

Montague: I started in Cornwall in May 1979 and when I arrived gassing was taking place. As a practitioner, I was never aware that gassing was suspended while Zuckerman sat. I know that farmers and senior practitioners in my area gave evidence to Zuckerman. All I remember post-Zuckerman and the movement to the clean ring strategy was the impression that it seemed to

[130] Sir Nicholas Soames (b. 1948) is Conservative MP for Mid Sussex. He was Parliamentary Secretary in MAFF from 1992 to 1994.

[131] Wildlife Link was formed in 1980 from the Council for Nature and the Council for Environmental Conservation. In 1990 it merged with the Countryside Link, forming the Wildlife and Countryside Link. In 1984 the Wildlife Link Badger Working Group published a report arguing that MAFF's policies were ineffective and should be reviewed. See Wildlife Link Badger Working Group (1984).

[132] The Zuckerman Report of 1980 had recommended a further review after three years of the problem of dealing with badgers infected with bovine TB. The review team, chaired by Professor George Dunnet (1928–1995), Regius Professor of Natural History at the University of Aberdeen, concluded that some form of badger control was necessary and proposed an interim strategy to cull badgers from farms with confirmed cases of bTB and the development of live testing (Dunnet, Jones and Mclnerney (1986)).

reduce the level of TB on the chronically infected farms but it was terribly resource intensive; the disease ran in front of them and they weren't able to get on top of the level of culling that was necessary. Clean ring strategy just involved moving outwards from infected farms until you got, as best as they could establish at the time, clean social groups of badgers.[133] Of course, every time you went out it increased by geometric progression, the number of setts that needed to be dealt with. I left Cornwall in 1987 really before Dunnet's strategy came into play, but my impression from Dunnet was that in those areas of the country where badgers had been killed regularly, Type I removals just continued.[134] I moved to Monmouthshire, South Wales, and TB emerged there between 1988 and 1991. We didn't really know how to manage the process with the mini panel.[135] When we eventually did, we did do some removals under the Type II arrangements where the mini panel used to authorize removals in a previously clean area. They seemed to be very limited and with what we know now about perturbation, you could argue that the upsurge in the graph in the incidents during the 1990s may have been due to some extent to the removals that were taking place under that policy.

Thomasin-Foster: John, I just wonder whether that slight upsurge was due to the fact that after the clean ring strategy we had the interim strategy and we were not permitted to trap badgers beyond or outside the boundary of the infected farm. I just wonder whether that was the reason if you had a sett literally 10 yards over the boundary of a farm and you were pretty certain that this may well be the infected sett, you were not allowed to touch it. Certainly from my chairmanship of the Badger Panel that was a feeling I had, but it was a retrograde step at that stage and we saw this graph of infection slowly creeping up, and then, of course, we had the live test and the rest is history (Figure 18).[136]

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[133] A clean ring strategy, recommended in the Zuckerman review, was applied from 1982 to 1985. Areas were kept clean by continued trapping for six months after clearing.

[134] Type I parish removals occurred where there had been one or more confirmed badger-attributed TB infections in cattle in the previous six years; Type II parish removals occurred in areas where there had been no confirmed cases of cattle with badger-attributed TB in the previous six years.

[135] The mini panel was a subgroup of the MAFF Consultative Panel on Badgers and Bovine TB, which considered the evidence to approve a Type II removal, where there had been no recent history of TB attributed to badgers.

[136] A live blood test trial to detect infection in live badgers began in 1994 in south-west England. However, the test only detected 41 per cent and it was suspended after 18 months pending the outcome of the Krebs review.

Figure 18: Badger being injected with anaesthetic under field conditions to allow blood sampling and testing for TB as part of the live test strategy

Montague: Just to come back on some of that. It was, I think, even more restricted than that, Mark. It was just the land where infected cattle had grazed, not necessarily the whole farm. So removal activity was focused on a very small part of some farms. In some farms it was the entirety. The live test pilot in the South West again suffered from resource issues. You will appreciate BSE was really focusing our attention at that time. I alluded to the fact that the incidents increased quite dramatically at that time – was it due to perturbation effect from the Dunnet removals? But, of course, the early 1990s is when these new areas just emerged from nowhere, as completely new molecular types.[137] Disease suddenly appeared in Herefordshire and Worcestershire. In Monmouthshire we had disease appear at the end of the 1980s, beginning of the 1990s. It had been clear of TB since 1955 and it has a distinct molecular type. Where had it been all that time? It was occurring in distinct geographical areas in mainly large, closed dairy herds, as closed as

[137] Mr John Montague wrote: 'Much of the work on spoligotyping has been done by Noel Smith at VLA Weybridge and his describing of a geographic home range for each diverse molecular type; spoligotyping data was used to unravel a host of breakdowns that occurred following re-stocking after the foot and mouth of 2001 where infection moved with purchased cattle.' Email to Ms Caroline Overy, 27 March 2015. For a discussion of molecular types of bovine TB see, for example, Smith *et al.* (2006); and for the post-foot and mouth analysis see Gopal, Goodchild and Hewinson (2006). The *Mycobacterium bovis* Spoligotype Database, supported by Defra and the VLA, has been set up by Noel Smith and Rainer Hilscher: www.mbovis.org/index.php (accessed 22 April 2015).

a dairy herd can be. It reappeared in Staffordshire. Interestingly, Staffordshire was in line for gassing in the late 1970s and early 1980s but it never took place. Disease went quiet in Staffordshire and reappeared in the 1990s. In Somerset, Exmoor flared up in the beginning of the 1990s. It spread across to Wiltshire and yet it isn't really spread, this is the emergence of new foci of infection mainly with distinct molecular types.

Williams: Can I ask you about when you were doing the clean ring strategy and interim strategy; was there any testing of badgers that were killed? Did that ever come up at all? Was there any testing of badgers for TB just to find out prevalence at all?

Montague: Again, I was a practitioner during the clean ring strategy. My reading of it was that, to establish whether a sett was infected or not, they trapped two and if either was infected it was considered to be a diseased sett and therefore the sett was trapped. I don't know whether all of those were subsequently post mortemed. But under the Dunnet removals I think they were all post mortemed and I think the statistics appeared regularly in the glossy brown booklet series, *Badgers and Bovine TB*, and in the back there was the number that had been taken by MAFF and the number that had been post mortemed as part of an RTA survey.

Meldrum: I did recently put some evidence to the Environment, Food and Rural Affairs Committee (EFRACom) and for that reason I went through the CVO's reports and pulled out some figures that I have here: between 1988 and when the cessation occurred of that particular policy following the Krebs Report, there were 1,600 badger removal operations and 13,000 badgers were taken and examined post mortem. So they would, I think, Fiona, have been examined post mortem, probably by you. Twenty-three per cent of them showed evidence of tuberculosis.[138]

Stuart: Yes, we did a huge number of post mortems at Weybridge but they were done in the veterinary investigation (VI) centres as well during that time. I was just going back to the live tests; I was involved in developing that so called 'Brock test'. Quite honestly it was not going to be a winner because it was an antibody-mediated test, and TB is a cell-mediated disease and antibodies are only produced in the very, very late stage of the disease. It

[138] In January 2013 Mr Keith Meldrum submitted a letter to the House of Commons' Environment, Food and Rural Affairs Committee on bovine TB vaccination. See www.publications.parliament.uk/pa/cm201213/cmselect/cmenvfru/writev/bovine/bovine.pdf pages 33–5 (accessed 23 December 2014).

has got a very low sensitivity, partly as a result of that pathology, that type of antibody test. It would only be positive on 50 per cent of the animals in late stages of the disease – it was not going to be a thing that worked in TB control. Also that was obviously before we knew about the infective consequences of perturbation and that's another reason why that policy probably wouldn't work.[139]

Grant: Keith, you were referring to the reluctance of Ministers to take effective action very often on this matter. One thing that comes to my mind was the protest movements associated with badgers were gathering new dimension and achieving new momentum. I think it was the Folkington Bowl in Sussex, where there was a bad infestation of bovine tuberculosis, and badgers in the area were suspected. It was proposed to carry out some clearance but in fact protestors camped out in the area and really prevented anything being done, particularly given the police seemed to be very reluctant to get involved in the matter. So there was a kind of new dimension in the 1980s opening up.[140] Civil servants, I think, found this quite challenging.

Meldrum: It was very challenging for our field staff and the people who were involved in badger removals; they were harassed and they were often threatened. They had paint thrown over their cars, they had manure thrown through their front doors, and they were really hassled. It was a high-risk piece of work that they were doing. It got to a ridiculous situation. I remember on one occasion, it was probably early on in my days in Tolworth, we had a row of houses on the outskirts of Salisbury Plain and they had badgers under their gardens, and they were starting to go underneath the houses as well. Somebody fell down a hole and broke their arm and somebody else fell down another hole and broke their wrist, and we had permission then, or permission was given, that we should remove those badgers. Not kill them, remove them onto a different part of Salisbury Plain. There was all hell let loose. The badger welfareists came in, and every time we'd trap them overnight they were released again. We weren't going to kill them, we were going to move them to a different spot because they were doing damage. So there was acute harassment and concern around the houses about what we were doing to badgers and they should not be touched at any cost. It made our life difficult.

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[139] Goodger *et al.* (1994). For an evaluation of the 'Brock test', see Clifton-Hadley, Sayers and Stock (1995).

[140] For a discussion on the Folkington Bowl protests, see Grant (2011).

Stuart: Just to follow on the comment about Folkington. When I started on TB at Weybridge it was just when that was happening and what we did do, though, was do a survey of all the small mammals that could be caught in that project area, they all came to Weybridge and were post mortemed and cultured for TB. As far as I can remember we either didn't find any or it was very, very low levels in all sorts of other mammals.[141]

Macdonald: Hearing people talk now, something else which I think has changed in an interesting way is what society and Secretaries of State have hoped to achieve by these various interventions. Years ago, I think I'm right in saying that people hoped that Zuckerman, Dunnet, or whatever, might actually solve in some sense this problem of TB in badgers. I think we've moved to a new world where both biologically and politically this is all about a marginal gain and the politically arduous part about it, and this resonates with what Keith was saying about what protestors protest about, is the judgement of how big an effect is worth it. So most recently, taking all the information from the RBCT and extrapolating from that as far as is reasonable because there isn't any choice, and looking at what the gains might be if everything went well over the Somerset and Gloucestershire areas that have been rolled out recently, the sort of marginal gains that might be expected on the basis of existing data were, and these figures are much bandied about, a 9 to 16 per cent reduction in herd breakdowns over eight or nine years. The confidence intervals on those expectations are so big that it might well work out that they weren't 9 to 16 per cent, they were significantly worse because the conflict of interest is so broad.[142] So the poor old Secretary of State is looking at a major intervention with financial implications, perhaps civil unrest implications, societal objections, and so forth, for what might be a very small gain over a very long period, and somebody sitting on a hilltop looking at the landscape has to decide whether they think it's worth it. I think the best expectation at the moment on the accumulating data is a pretty small marginal gain, making the political decisions quite complicated.

McGlone: If I could just pick up on that as a resident of Gloucestershire who has seen what's happened. When I left the Wildlife Trust I was no longer part of a group discipline, I became me and I was able to do things that I wished. So I

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[141] Wilesmith *et al.* (1986). In this study *M. bovis* was not isolated in any of the 15 species of mammals investigated.

[142] See the discussion in Macdonald and Willis (2013).

went to see the Police and Crime Commissioner and gave him what I suppose is called a heads-up on what was likely to be heading in his direction if a badger cull arrived in Gloucestershire, just from my reading of the likely effects. At the second meeting, Chris Cheeseman came with me, and during that meeting I could see the Police and Crime Commissioner's face fall because he had not understood what the badger cull might be. Everything that we talked about came to pass except no one got shot, which is fantastic. No one was seriously hurt during the badger cull in Gloucestershire in 2013 and that was brilliant. But the civil impact has been enormous and the police were not ready for it – I'm able to say this because I actually ended up on an advisory group under Operation Themis that was set up within Gloucestershire to try and cope with it.[143] The police had to learn to change their tactics to deal with middle England. These weren't the cranky groups they were dealing with, these were librarians and people who worked in the County Council, people with professional knowledge who you wouldn't take a second glance at if you met in the library. These people were so motivated by a sense that this was not correct, and I think that is one of the really biggest changes that I've seen. I don't think it was anticipated and it is political with a small p. It's about making judgements and it's about making use of resources. In fact, last night there was a webinar where the PCC actually grilled his chief constable to ask questions about the badger cull in the public eye so that people could hear answers to questions because the police took real damage from this from both sides. They were criticized for not looking after local communities; there was a letter from three MPs written criticizing the police.[144] At the same time they were then criticized by people who had been in the field who felt that their interests weren't looked after as civil rights. So it's caused an enormous set of ripples that have gone right across the county and I think that's something that can't be underestimated but has never been seen before. I think that's the side of the badger cull policy that we have now, which really has had probably the biggest impact.

Meyer: Just back to the perturbation effect. I remember in the mid-1980s with cage trapping going on, Roger Symes, I think at Bristol, designed the 'clean ring strategy' in which contiguous setts were removed from around all

[143] Operation Themis was the Gloucestershire police's response to the badger cull, which started in 2013, to maintain public safety, to report incidents of crime, and ensure people could protest peacefully and lawfully.

[144] Geoffrey Clifton-Brown MP for the Cotswolds, Mark Harper MP for the Forest of Dean, and Laurence Robertson MP for Tewkesbury wrote to Gloucestershire's Chief Constable in November 2013 expressing concern that the police were not properly responding to allegations of criminal behaviour.

infected setts. So they would then take out a surrounding group of setts which I think demonstrates that perturbation was understood at that time and that badgers were going to travel. They tried to deal with that by taking out this clean ring. Is that right, Keith?

Meldrum: Yes, it was quite clear from the work done in Gloucestershire that there was a perturbation effect; it was accepted certainly at that time. I always accepted there was a perturbation effect and therefore I was a bit surprised at some of the discussion today that it was a new phenomenon. I think it was understood by our scientists. Just let me put something in context. When I was working in Tolworth, Ministers spent a lot of time talking about these sorts of projects. It wasn't just a chance discussion. First of all there would be scientific advice coming forward. That would be turned into a submission prepared by a civil servant – Robert Lowson should have been here today, he was one of those guys who prepared submissions[145] – a formal, very detailed submission with background and then recommendations. Then we'd have a meeting with the Minister, maybe with all three of them, the Minister as he was then and the two Parliamentary Secretaries, maybe even four of them. We would discuss it with the Permanent Secretary and go through it in some detail. Often they would call for more evidence and advice. But I was seeing Ministers because of BSE and other reasons frequently and it would come up time and time again and we had a great deal of discussion. You're absolutely right, they were aware and they were concerned about the public outcry; of course they wanted to get re-elected, it's quite simple! There's a small p or a big P involved in this, they want to be re-elected. Every morning you can see the press secretary, the Bernard Ingham of No. 10 rushing down to see the Minister with a pile of press cuttings.[146] You can see the Minister going through these very quickly but also very carefully to see what the headlines are. Are there any bad headlines? They were very much aware of the public perception. It's much, much more difficult now because the advice when I was around came up from civil servants to the Minister. It doesn't happen now. In England there is now an Animal Health and Welfare Board for England and all the strategic advice goes through them and they advise the Secretary of State as to whether or not he should get involved in any more badger culling.

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[145] Robert Lowson (b. 1949) worked at MAFF and Defra from 1970 to 2007. He was Head of Cereals, Milk, Animal Health, and Agricultural Resource Policy Division between 1983 and 1994.

[146] Sir Bernard Ingham (b. 1932) was Chief Press Secretary to Margaret Thatcher between 1979 and 1990.

I think that is probably a retrograde step. I think Ministers need to be closer to the guys who are giving the advice and the scientists who are producing the evidence on which this advice is based.

Williams: Keith has probably answered some of my questions. I was going to say, do you think the Government listened to science then more than they do now? But it sounds like they've always listened to some of it, the bits they want to. Would that be fair?

Meldrum: Yes. Please don't accuse me of going back to BSE, which was a one-off, where we knew absolutely nothing when we started. Yes, the scientific evidence and the advice were absolutely crucial, very important. I would never take anything forward to a Minister on BSE unless it was supported by scientific advice or scientific opinion, in many cases because we didn't know the answer, but you had to make the best guess. So, yes, they were very keen on that, and although nowadays you hear: 'all decisions are made on science, are science based', they were actually in the main and the Ministers would listen to what was said on tuberculosis and the relationship between cattle and badgers and so forth. Make no mistake, the Ministers I worked with, with no exceptions, were extremely able and extremely bright.

Stuart: I know it's relatively recent but one thing that happened was after Godfray's report on the reactive culling, one of the recommendations in that was that a scientist was embedded in the policy team for TB, and that was me. I set up a group of three or four people – okay, I knew about TB and that's serendipitous because I'd worked on it myself – and our job was to gather the information and the experts from outside to get the evidence, to then inform Ministers and we worked extremely closely. We were in the policy group. John headed the veterinary group, I headed the science group, but we were actually embedded with policy makers and it worked extremely well at that time. We saw Ministers regularly, weekly, or even more often than that at some points, when things were really happening, and they certainly took a lot of notice of the science.

Montague: Yes, I just reiterate Keith's point; I think Ministers were very astute, very conscientious, really wanted to do something, wanted to make an impact but they had a gut feeling one way or other on badgers. I didn't deal with your 15 Ministers, Keith. I had four administrations I think I dealt with, and they had a gut feeling for where they wanted to go on badgers and for à la carting the evidence to suit their political position one way or the other. There

was a sea change when the Coalition came in in 2010 on the basis that it was one of the Coalition agreements that they would take forward badger culling, it was in the manifesto of both Liberal and Conservatives in 2010, and there was a junior Minister, Jim Paice, who really drove it forward.[147] Prior to that the Labour administration were reluctant and they saw badger vaccination as the way forward. But the evidence they were always presented with was what we know and what we don't know, and it's the uncertainty which makes them go one way or the other depending on what drives them politically.

Meldrum: If you're looking at Wales in the last two or three years, I think we have an extremely able Chief Veterinary Officer, Christianne Glossop. She was making a strong case for the culling of badgers in Wales, supported entirely by her Minister. Then a new Minister comes in and the whole policy was changed.[148] Poor Christianne had a terrible presentational job and then had to say: 'Well, I was supporting culling a few weeks ago, now I have a new Minister I'm now going to support vaccination.' Not easy but that just shows you what happens. A new Minister and this could happen after the next General Election. A new ministerial team and they may have a totally different view on all this because it is so politically sensitive.

Stuart: That's exactly what happens, of course. Keith knows better than I do but that happened, as John said, several times during our 10 or 12 years in the TB policy area. The thing is with the TB evidence, especially once the ISG had reported, in fact you could argue the case either way and of course the evidence was being accumulated post-trial, which was very important, and Christl Donnelly's further calculations on what was happening several years after the culling stopped, showed actually that the effect of culling was increasing still. But you could use the evidence to argue either for vaccination or culling or both and so you know there's a massive amount of work behind the scenes being done on all those potential policies because you never know when you're going to get a new Minister. You usually know when you're going to get a new administration, but they change and it's just very political.

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[147] Sir Jim Paice has been the Conservative MP for South East Cambridgeshire since 1987. He was Shadow Minister for Agriculture and Rural Affairs from 2004 to the General Election in 2010, after which he was Minister of State for Agriculture & Food in the Coalition Government until 2012.

[148] Professor Christianne Glossop was appointed the first Chief Veterinary Officer for Wales in 2005. The Welsh Labour/Plaid Cymru Coalition Government had proposed a pilot badger cull. Following the 2011 election of a Labour Government, this plan was scrapped for a five-year vaccination programme.

Montague: I think all I would add is whenever you have a change of Ministers, with TB being so complex, it really takes them about nine months before they get their mind around the issues, despite us seeing them probably twice a month.

Meyer: I wonder if these chaps here who have much closer contact with the ministry that I ever had, can tell me whether there's any truth in what I was told by one ministry scientist that his top priority was to prevent the Minister from any possible embarrassment. That was his number one priority. Now would you say there is any truth in that?

Meldrum: My relationship with Ministers was totally open and that was not part of my remit. I simply put to them the best advice I could, based on the evidence and advice that I received, in turn. It wasn't my own advice, it was from a team based on what came forward, in many cases based on very clear scientific evidence and advice. I was never going to advise a Minister to do something that I thought was wrong and therefore could cause embarrassment.

Thomasin-Foster: Two things: first of all, last week I attended a Defra biosecurity, cattle biosecurity, seminar and it was held with about 40 farmers from across the country. I was actually very depressed because we were just going over the same old ground that we'd gone over 15 to 20 years ago on biosecurity. We were talking about trying to keep badgers out of water troughs, etc. etc., and pre-movement testing, and all the rest of it.[149] There are a whole mass of issues which, as I say, last week we were just reinventing and indeed the Badger Panel, under my chairmanship, had discussed those things. Coming back to the more modern situation, and again mentioning the mini panel, the mini panel on Type I parishes and breakdowns had a whole mass of detailed maps of where the badger setts were, the infection of that particular time, where there were RTAs picked up, a whole absolute host of information. As we well know, some badger setts have been dated to be 2,000 years old. So we knew at that stage quite a lot about the geography of the badger populations on farms. After 1997, when my panel was wound up, I went back to Elliot Morley and Jeff Rooker and asked them what had happened to those maps and all that information, and I was shattered to be told that it was all destroyed.[150] Now I thought that was a great, great loss of historical information that we could have one day perhaps used.

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[149] For a discussion of biosecurity in relation to bovine TB, see, for example, Enticott (2008).

[150] Elliot Morley (b. 1952) was Fisheries Minister from 1997 to 2003, then Minister of State for the Environment and Agri-Environment in Defra until 2006. Jeffrey Rooker, Lord Rooker (b. 1941) was Minister of State for Sustainable Food, Farming and Animal Health in Defra from 2006 to 2008.

Montague: I don't know whether Ministers spoke from the knowledge base that they would have needed, but my office was based at Aston Down, which was the Stroud end of the wildlife unit and there was the Truro end. We had filing cabinets full of Interim Strategy, Badger Investigation files. They would have been archived after a certain period of time, they would have gone off to the National Records, and they would have naturally been destroyed after a period of time. There will be a proportion, some of them, and including all the RBCT data, sitting in a national archive somewhere. I guess there will be some of the Badger Investigation data but I don't know that it would go right back to 1986.

Thomasin-Foster: John, I have the letter from Eric Morley stating that it was all destroyed.

McGlone: Just to take the historic perspective again. In terms of one of the changes that we've seen, and this is back to the politics of it, is the ability of groups and the general public to lobby on a particular subject and, over the sweep of the time that we've got for this oral history review, that has changed dramatically. When I started work, it was the very occasional letter written to the local MP on a subject. It wasn't universal even within the Wildlife Trusts that that was common practice. It was a skill that was still being developed at that very simple level and I think what we've seen over this period of 30 to 40 years that we're looking at, is that that has changed dramatically and now it is routine and now we have e-petitions that are almost instantaneous. On Twitter if you're 20 minutes late with something it's old news because everybody knows it. The whole perspective has changed dramatically and that's where this subject has become much more politicized than it had done previously because it's now in the grasp of citizens to be able to express their opinion publicly, quickly, and in an organized way. We've seen last year the No. 10 e-petition that was the largest ever response to any petition run on the Downing Street website, or Downing Street system.[151] That's a really big change that influences Ministers, but it may not influence Ministers as much as perhaps I'd understood from the point that Keith made about the watch that was put on press. Now I know that Defra have the prize-winning Twitter team. They use Twitter more skilfully than any other government department, which I think is really interesting. And I also know that the NFU (National

[151] The e-petition started by the guitarist Brian May to end the badger cull was the most signed e-petition on the Government website, attracting 304,253 votes between August 2012 and September 2013. See http://epetitions.direct.gov.uk/petitions/38257 (accessed 27 January 2015).

Farmers Union) put in place a Twitter mechanism and encourage their county chairs to use Twitter. These are really big changes – this technology didn't exist in the early part of the period that we're reviewing. But nevertheless it is about social engagement and it's about trying to influence policy, which is based on something very complicated. It's been very interesting to see this unfold and it's not going to stop. I think the changes that are under way are really significant and the political implications for the next election of a policy that was started a couple of years ago of pilot badger culls. We've never actually seen anything like this that has such a direct relevance and that one can almost predict that there won't be a badger cull unless there's a clear Conservative majority. These are not the kind of predictions that we would have made if we'd been sitting here 15 or 20 years ago talking about this issue. It's a completely new dimension, which is hugely important. It's very interesting to try to imagine what this might turn into in the future, if you were doing an oral history review in 20 years' time, looking back nostalgically at the days when Twitter was new, and weren't we naive? It's very hard to see where it's going, but certainly it is influencing policy and it's being used more skilfully. I imagine that government departments will get much better at using it than they have been; that seems to me the logical development because it's an immediate way of communicating with citizens on complicated issues. Although Defra may have been good, the best at it at the moment, I would say it's not good at it at all.

Meldrum: I think there is a downside to this, I think it's a very good point you've made. I'm actually quite relieved that I'm no longer working in government because I think I would be quite alarmed, not only by the volume of emails but also by Twitter and Facebook and everything else that comes at you from all directions, which you've got to take into consideration. My worry, and this is actually post-BSE Inquiry coming out, is that this tends to persuade government to do nothing because whatever you do you're going to get criticized. I am certain that if we had taken some of the actions that we took in 1988 and 1989 on BSE now, we would have had a storm of protest from farmers and others about what we proposed on the feed ban.[152] It worries me hugely now that this is going to stop them making the decisions that they really need to make in order to pre-empt some awful disaster. I am very

[152] The feed ban, feeding ruminant protein to ruminants, was introduced in the UK in 1988 as a method to prevent the spread of BSE. In 1994 the EU banned the feeding of mammalian protein to ruminants and in 1996 in the UK the feeding of mammalian meat and bone meal to all farmed livestock was prohibited.

worried about what's happening in Europe, in the European Union. I'm even more worried about the cutbacks in resources now in Defra and whether they are able to cope with any serious disease problem that may come in the future.[153] We are going to have some more disease problems and it may well be that a new government will say: 'We've got to cut back on the TB control programme because we simply can't afford it.' I'm worried to death that Defra is facing a massive challenge at the moment on finances and this is only part of it – what the public may say.

Meyer: I've heard it said by a political analyst that if Twitter had existed at the beginning of the last century, the First World War would never have happened. One can think of the Arab Spring maybe as some evidence to support that. I thought Gordon's analysis of that was masterful; that was very good, Gordon, thank you for that.

Clark: The Hon. Anne Main, Conservative MP for St Albans in our county, called a private members' motion about the inhumanity of the cull, speaking against her own government as it were, and she won, or the debate was won, by 219 to 1.[154] I watched the debate on BBC Parliament coverage and all the points that arose were very interesting. To have one of their own backbenchers opposing the policy must make it extremely difficult for the Government.

Grant: I wonder if we could perhaps move on a little bit to the Badger Panel and the purpose of the Panel and what it achieved or didn't achieve; it would be perhaps interesting to review that.

Thomasin-Foster: What a question. They chased me as being independent when I was appointed by Michael Jopling, a long time ago, and as soon as I was appointed MAFF very sweetly indoctrinated me.[155] I went down to Gloucestershire and had two or three days down there, looking at Woodchester

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[153] It was reported in January 2014 that since 2010 the Defra budget had been cut by £500 million and that the department would have a further reduction of £300 million by 2016. Environment, Food and Rural Affairs Committee. Ninth Report Departmental Annual Report 2012–13, online at www.publications.parliament.uk/pa/cm201314/cmselect/cmenvfru/741/74102.htm (accessed 15 April 2015).

[154] Anne Main (b. 1957) has been Conservative MP for St Albans since 2005. For the debate on badger culling see the Parliament website at www.parliament.uk/business/committees/committees-a-z/commons-select/backbench-business-committee/news/mps-debate-the-badger-cull (accessed 5 January 2015).

[155] Michael Jopling, Lord Jopling (b.1930), was Minister of State for Agriculture, Fisheries and Food from 1983 to 1987.

Park and several other things, and it was an eye-opener for me. What did we try to do? I suppose my objective was to try to find some form of consensus, some form of means of managing the disease. I was very aware, and at the same time, I was involved with the CLA, the Country Land and Business Association, and with the environmental adviser there, Dr Woods. He and I had a long discussion about whether it was going to be impossible in future for certain areas to have cattle. He was of the opinion that we may well have to move away from that. At the moment, where I farm in a small way on Exmoor, I'm straying a little bit but I think this is where it's quite interesting, we have Natura 2000 sites of open moorland, which are desperate for cattle grazing but no farm around there really wants to put cattle on these commons because of the level of TB.[156] So again we will be faced with how we manage the countryside. So I come back to where I started – there's a lot about management of the countryside, of farm management and how we deal with things. Sheep on the moorland are pretty useless. We've got ponies up there, which are better than sheep but not quite as good as cattle. Going back to the panel, I tried to get some form of consensus and in many ways I hope and think I did. We spent a lot of time discussing matters and we had verbatim minutes, which I thought was important. Obviously they were confidential but we did have full sets of minutes and I think we moved in the right direction. At the end of the Badger Panel when the Government changed in May 1997, I had two or three meetings with John Krebs and I tried to take to him what I took back to Elliot Morley and Jeff Rooker, that I felt if they moved too quickly without continuing some kind of badger removal that we would lose control of the situation and it would get worse – watch what was happening in individual Type I parishes and the level of breakdowns. I took that to them and they didn't actually take that advice. John Krebs explained to me at great length how he was incredibly frustrated because he wanted to be able to do his experiment over, I think, two or three years. He didn't have the funding to do it, which annoyed him, and, of course, foot and mouth then intervened and made it worse, so I think it was over five years in the end. During my 10 years chairing, we did hold the disease at a lowish level but we didn't find a solution. Now I feel quite frustrated that we didn't go on and hold it there but I said earlier on, a lot of it is down to farm management, the way the countryside is managed, fencing, maize growing, cattle movement, etc. There's a lot of

[156] Natura 2000 is an EU initiative set up in 1992 to create a European Union-wide network of conservation areas to protect valuable and endangered habitats and species. See the website at http://ec.europa.eu/environment/nature/natura2000/index_en.htm (accessed 15 April 2015).

that there, which we haven't properly looked at yet, but I suppose, looking back, what are we trying to do? We're trying to deal with a very complex thing and no single solution is going to be the solution, it's going to be a complete composite of measures. So that's the résumé of my 10 years.

McGlone: I was a member of the Panel, I was the third member drawn from the Wildlife Trusts: Morley Penistan; an immunologist/haematologist, Professor Humphrey Kay, who was chairman of the Wiltshire Wildlife Trust; and then myself.[157] I would like to compliment Mark actually for being neutral; I haven't seen him since the last panel meeting, which was a while ago, but he did that rare thing and he steered right down the middle on something which is a very difficult issue and I think that was a rare trick to manage. I only attended two or three panels, I came in towards the end, and I found it to be a very valuable source and a very good place for well-balanced debate. I wasn't given any briefing to the contrary before I attended and I think that was the view of my two predecessors. From that perspective it was something that was very valuable and played a key role, and it's a pity that there isn't a forum like that now. The groups that have been set up, and one of them was just referred to, they aren't balanced.[158] They are set up with a very particular perspective and they don't cover the full spectrum, which is a shame because it has led to greater polarization than there was; clearly there were different views at the time, but it wasn't as badly split as I think this whole issue has become.

Meyer: I think I preceded you, Gordon, on the panel. Mark was the chair and I represented the National Federation of Badger Groups, which was a precursor to the Badger Trust. I don't think my involvement was very great, I don't think I contributed very much. I was too young and inexperienced and a bit in awe of Lady Bolitho and Don Jefferies and Colin Booty and people like that around me who seemed to know a lot more than I knew.[159] But I did find it a very useful experience and I remember your chairing of it, Mark, and you were very fair, I think. I would just like to concur with what Gordon said then.

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[157] For Morley Penistan see note 39. Professor Humphrey Kay (1923–2009) was a pioneer in the diagnosis and treatment of leukaemia. He was a haematologist at the Royal Marsden Hospital from 1956 until he retired in 1984. During his retirement he was an active member of the Wiltshire Wildlife Trust and from 1988 to 1998 was a member of the Badger Advisory Panel.

[158] See the comments on the Krebs Committee on page 50.

[159] Lady Bolitho represented the Country Landowners' Association, Don Jefferies the Nature Conservancy Council, and Colin Booty the RSPCA.

Grant: Then we come to the position of the commission of the Krebs Report. We ought to consider how that came about and why it was thought to be necessary to have that commissioned.

Meldrum: I thought you might ask this question. I can't remember. It normally means if the Minister wants to have, or agrees to have, an inquiry conducted by a very eminent scientist then you really are in trouble. That means that they, and probably we, the civil servants, don't know which way to go and we need some help, simple as that. We were floundering at the time. The number of cases was going up extremely fast and into new areas and we weren't on top of it so I think they were trying to get some clear advice. But while the fundamentals of where we're going forward were clear, involvement of badgers and other things to do with movement of cattle from farm to farm, the whole situation needed to be reviewed again because we were getting nowhere, and Ministers I'm sure would be advised accordingly. I can't remember this exactly, but I'm pretty certain they would have been advised that was the way to go because I was given the authority then to approach John Krebs and ask him whether he would be willing to take on the chairmanship of this committee.[160]

Williams: The purpose of the Krebs trial was to test whether killing badgers made any difference to cattle TB. That was the sole purpose of the trial, wasn't it?

Montague: Krebs recommended a randomized, replicated, controlled experiment which was then taken forward by John Bourne and his Independent Scientific Group (ISG) in the terms of its design.[161] I think it would be wrong to infer that it was actually testing how successful the culling of badgers would be in reducing TB in cattle because, as I suggested to you earlier, I'm not convinced that the balance of that committee was right and I don't think the assertiveness of all committee members was as good as it might have been. In the end it may have been testing the perturbation theory a bit more than

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[160] For the committee members see note 112.

[161] Professor John Bourne (b. 1937) was Professor and Head of the Department of Veterinary Medicine at the University of Bristol from 1980 to 1988; Director of the Institute for Animal Health of the Biotechnology and Biological Sciences Research Council (BBSRC) (formerly Agricultural and Food Research Council (AFRC)), from 1988 to 1998, and Chairman of the Government Independent Scientific Group for Control of Cattle TB, from 1998 to 2007. See Independent Scientific Group for Control of Cattle TB (2007). For a number of documents and reports of the ISG see the UK Government Web Archive at: http://webarchive.nationalarchives.gov.uk/*/http://www.defra.gov.uk/animalh/tb/isg/index.htm (accessed 15 June 2015). For recent discussion and analysis of the RBCT and consideration of its wider implications, see Cassidy (2015).

actually how successful culling badgers was in the control of the disease. That's from someone who was trying to do the job at the coalface and attended, I think, 88 all-day ISG meetings over six or seven years.

Williams: Regarding the selection, didn't they just choose the most eminent scientists in the field that they could find, irrespective of their backgrounds? Or is that a bit naive of me?

Stuart: Well, there were some huge gaps because they didn't have a veterinary epidemiologist. The vet that they had, Ivan Morrison, was an immunologist who had worked on East Coast Fever and exotic diseases. They didn't have anybody who had worked in TB apart from John McInerney, who's an agricultural economist who had been on the Dunnet panel.[162] I tend to agree with what Keith said earlier, it wasn't a broad enough group basically. Of course, John Bourne himself is a vet but he hadn't had any particular experience in TB, apart from when he'd been in practice decades before.

Meldrum: Yes, I think we made a mistake fundamentally. We invited John Krebs to chair this committee but we should have had more involvement with the composition of the committee.

Montague: Just on the basis of the design of the Randomised Badger Culling Trial (RBCT), David, at the outset it was quite clear that it could not establish what Krebs had wished it to, which would be the contribution that badgers made to cattle TB, for two reasons. First of all, we were using a method of removal that did not remove 100 per cent of badgers; secondly, it was not compulsory and therefore we didn't remove badgers over 100 per cent of the land. So it was a compromise, a real world compromise, that probably would be what one would be able to do going forward, but it couldn't actually quantify the exact contribution of badgers to bovine TB because there were badgers left in the area subsequent to culling.

Thomasin-Foster: One question, I don't know who could answer this. In Ireland, removal is done by snare and I think snares are still in use. Just a simple question: we moved straight from gassing to trapping, we never went through snares, did we?

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[162] Professor Ivan Morrison was Head of the Division of Immunology and Pathology at the University of Edinburgh from 1990 to 2002, after which he became Professor of Immunology at Royal (Dick) School of Veterinary Studies at the Roslin Institute at the University of Edinburgh. Professor John McInerney (b. 1939) was the Glanely Professor of Agricultural Policy and Director of Agricultural Economics Unit, University of Exeter, from 1984 to 2002.

Stuart: No, we didn't use snares as far as I know but there was some research done on snaring actually – I think it was done at Porton. Basically it was deemed politically unacceptable. I presume it probably was a ministerial decision, they didn't want to go down the route of snaring in this country for badgers.

Montague: I can't add more, other than looking at the history of this – prior to MAFF gassing policy between 1973 and 1975 there was some licensing of farmers that allowed snaring and shooting of badgers. We didn't contemplate snaring for the trial because we hadn't done any work on snaring at that time. We then subsequently did do some work on snaring, including assessing the Irish situation, and also I'm not absolutely convinced I know when Ireland started culling badgers – I suspect it was in the 1980s. We have seen the snaring they use there. Experts went over, thought it was inhumane, came back to this country, tried to develop a humane snare, which couldn't catch anything basically.[163]

McGlone: I went across to East Offaly just as an information gathering exercise in the Republic of Ireland, and met the team there to talk about how they were working.[164] I got the impression that it was fairly indiscriminate in the sense that snares were used in the countryside and they caught badgers. My view then was that it was the kind of intervention with wildlife that wouldn't have been acceptable here because they weren't particularly focused on the time of year and whether or not they took out nursing females and any of the things, which would have caused a big reaction here even in the 1990s. In terms of the Krebs Report, I've just looked up on here that I gave evidence alongside Simon Lyster, who was then DG of the Wildlife Trusts. Interestingly, I say interesting because I was the person who was steering it, the Wildlife Trusts' position was against the Krebs review because we felt there was an awful lot of money that could have been used to go into badger vaccination, badger and cattle vaccination, which was our simplistic view in those days.[165] Here we are quite a long way later and we still haven't moved

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[163] Defra (2007). This report concluded that the success in trapping badgers using this snare was too low to be viable and that trapping using this method could result in injury to the badgers.

[164] The East Offaly study in County Offaly, Republic of Ireland, ran from 1989 to 1995 and proactively removed badgers using snares from an area 528 km^2, with a 1.6-km-wide buffer zone surrounding it. For a discussion of the results of the project, see for example, Eves (1999).

[165] A letter to the Ministry of Agriculture, Fisheries and Food, Tolworth (27 February 1998) and a memorandum (13 January 1999) submitted by the Wildlife Trusts regarding the Krebs Report, along with the examination of Dr Simon Lyster and Dr Gordon McGlone as witnesses, can be accessed online at www.publications.parliament.uk/pa/cm199899/cmselect/cmagric/233/9022301.htm (accessed 7 January 2015).

forward. It's interesting, looking back on it, that the biggest source of field data, the biggest field experiment of its type anywhere in the world at the time, didn't look entirely sensible from groups that then came to welcome some of the public findings. Then you move forward a bit and find that there is actually considerable controversy about the interpretation of those findings as to whether or not culling badgers does or does not make sense. So there was controversy before the field experiment started and there is still controversy over interpreting the outcome of the data and what that means for policy, and hence what the arguments that we've seen over the pilot badger culls and what Christl Donnelly's statistical analyses really mean. They can be taken two ways in the same conversation by two different people. An awful lot of money has been spent and we're still not necessarily socially very much clearer than we were before it started. It is still as complicated as it looked when we went into that exercise.

Montague: I think the trial yielded one benefit, which was that categorically it put to bed the argument whether or not badgers played a role in the epidemiology of bovine TB. Up to then, I think it was Keith who made the point that whenever we had meetings with a broad church of an audience there would always be wildlife groups that did not accept that badgers were involved in the epidemiology. I think the other thing that the trial did, was that there was a whole lot of related research that was bolted onto it that considerably increased our understanding of the dynamic of the badger population around perturbation, their impact on other species, we've already alluded to the RTA survey that went alongside it and the other species work. I would agree that the actual impact of culling is open to variable interpretation despite the considerable sum of money that was spent trying to do that job.

Meldrum: I'm summarizing, but the available evidence, including the effects of completely removing badgers from certain areas, is compelling and certainly that is what Krebs was trying to do, to come to a view on that.

Do you want to move on to vaccination because it's a fascinating area? I'm massively disappointed that the scientific community has not been able to develop a vaccine that is more effective than BCG – Fiona, you can comment on that. I think it's a very important area and I have fought for years and years, since 1992 or 1993, to get a decent vaccine for use in badgers, and certainly the indications have come out of Wales, and indeed from England, that the cost of vaccination of badgers is unbelievably high.

Montague: I've only read in the veterinary press but Wales reported costs from last year and the year before and they've gone down slightly in the second year, it is in the £600s.[166]

McGlone: Before I left the Wildlife Trusts I started a badger vaccination programme in Gloucestershire in 2011, and the purpose of that was to find out whether we could do it and how much it cost and publish the data, the costs. It's been really interesting and again the fact that this is in the public domain and there is a public report on it, that the cost per badger was about £220–£230.[167] But that figure just doesn't register. The Wales figure, the gold-plated, public servant driven, no cost-cutting badger vaccination thing is the only figure that's ever used. It's used by MPs who I have told personally that actually you can do it for a third of the price if it's done in a different way. That just comes back to the kind of fixed views that are held and that even where evidence is gathered it doesn't necessarily influence in the way one might have thought. I think what's interesting now is to see whether or not badger vaccination in its current form can be rolled out more widely using voluntary groups. I think that's something that one can only assess by seeing it. David Williams knows about that because the Badger Trust has done some badger vaccination itself. The Wildlife Trusts have got a programme running across a number of counties and are building expertise but it's very small beer in terms of hectares; these are small, still tentative first steps.[168] It's not a systematic programme but there is no strategy behind it and I have been puzzled that there has been no interest within Defra to actually steer or influence how badger vaccination, which is taking place, could be done in a more strategic way. I still don't see a change in that direction. It's as if it's not our job to try and make the work that's happening useful. Thirdly, there is no metadata analysis of the badger vaccination that's taken place in England and there's four years' data now that's gathered in the Gloucestershire deployment

[166] It was reported at the end of January 2013 that in Wales it cost £662 to vaccinate each badger; http://www.fwi.co.uk/livestock/badger-vaccination-cost-revealed.htm (accessed 15 April 2015).

[167] For details of the practicalities and costs of badger vaccination carried out by the Gloucestershire Wildlife Trust Nature Reserves Badger Vaccine Programme, see the 2012 Report online at www.gloucestershirewildlifetrust.co.uk/sites/default/files/GWTNRBVD%202012_1.pdf (accessed 21 April 2015).

[168] The badger vaccination programme started by Gloucestershire Wildlife Trust in 2011 was the first non-governmental vaccination programme. There are now ten Wildlife Trusts running vaccination programmes and three further Trusts about to start programmes. See *The Wildlife Trusts' Badger Vaccination Reports 2011–13* (published August 2014) online at www.wildlifetrusts.org/vaccreport (accessed 21 April 2015).

– nearly a thousand badgers a year – and no one has yet looked to see whether there's any associated reduction in bovine TB in the cattle in that area. More alarmingly, I don't even think the future of that deployment area, the funding for it, is safeguarded and it's the only one that's left of the original six that were planned.[169] So badger vaccination is a little bit flaky. I know it's only a tool but we kept hearing from our politicians that every tool in the box must be used but they seem fairly determined to overlook badger vaccination. That's my personal view, that it has not received the support that it could have done when there was a public interest, and certainly no public antipathy towards it. It seems to me a missed opportunity that is still not really being pushed forward.

Meyer: We seem to have moved on a little bit but, regarding snaring, I'm totally opposed to it, let me say, but I've been told that it is actually quite humane. The problem is that the snares have to be visited every one or two hours, which of course makes it impractical and probably very expensive. That's one reason why I think snaring hasn't been used in this country. The other quite important point is about wildlife groups. I don't think it is that wildlife groups deny the involvement of badgers – what they object to is the association of guilt that it is the badger which is responsible for the transference to cattle. It's not that they deny that badgers actually pick up and can carry and act as a reservoir for the disease, what they object to is the automatic inference that it is the badger responsible for the onward transmission to cattle. That's my understanding of it.

Stuart: I just wanted to say in response to a point that Keith made, wishing for a better vaccine. In human medicine, BCG, which was discovered in 1922 or something like that,[170] is still the vaccine that's used worldwide and there have been hundreds of millions of dollars, if not much more than that, spent on research in trying to get a better vaccine for TB because it's known that the BCG does not work very well. It's partly that, as I referred to earlier, the nature of TB is chronic intracellular disease, and it's just a very difficult disease to vaccinate against. Anyway, in human medicine no better vaccine has been found. We have not got the resources that can be put into the research. We use BCG just as a spin-off from the human vaccine. We've licensed it for badgers, which required a huge amount of work. When I was working in this

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[169] See pages 83–4.

[170] Calmette *et al.* (1927).

area, we spent over £20 million over a period of about 10 years, so from about 2000 to 2010, on vaccination research and licensing. So we did spend a huge amount of money. It was nearly half the amount that was spent on the RBCT so it wasn't neglected but it was there in the background. The political push was on culling. We had this short time when Hilary Benn was Minister from 2007, it didn't seem for a very long time, when vaccination was back on the agenda as the primary tool.[171] I think everyone's aware that, with the use of BCG in cattle, which is probably a much more sensible approach, we've got the legal issues with the EU. It's illegal to vaccinate cattle against TB because it interferes with the diagnostic skin test. That's not going to be a quick fix but we are trying to look at a diagnostic test that will differentiate between infected and vaccinated cattle.[172] Going back to the badger vaccination, I think the reason that Defra have not followed up more the use in the Wildlife Trusts is because it was backed as 'a good idea' and Defra licensed the badger vaccine, but there was no intention of a scientific trial to be set up because it would have to be on the scale of the RBCT to demonstrate an effect. We all know that that's just on the absolute borderline of being able to demonstrate an effect. As we said, you could argue it both ways. Vaccination is probably going to be even more difficult to show an effect from the modelling that we had done. We've also got, still going on I believe, a push to try to develop an oral vaccine which, if you had such a thing, would be a much more sensible approach in a wildlife population but it's not going to be easy. There will be not be a quick fix, I'm afraid, mainly due to the nature of TB.

Williams: Yes, the oral vaccine would be the answer, to make things much, much easier. I understand that delivery is the problem, and acceptance.

Stuart: The problem actually is in the microbiology because you have to get a huge dose of the live organism, BCG is just attenuated *M. bovis*, per ml of vaccine and it's almost impossible to get that. So it's very, very expensive to make an oral formulation and then you've got to keep it alive in the countryside, and it's got to be a formulation in bait the badgers will take. So there are masses of hurdles to developing a good oral formulation.

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[171] Hilary Benn is the Labour MP for Leeds Central. He was Secretary of State for Environment, Food and Rural Affairs from 2007 to 2010. In July 2008 he announced that the Government would not issue licences to cull badgers and would invest £20 million into vaccination research; for his announcement in parliament, see www.publications.parliament.uk/pa/cm200708/cmhansrd/cm080707/debtext/80707-0004.htm (accessed 20 April 2015).

[172] See page 83 and note 174.

Williams: The cattle vaccine is going to be even more expensive to set up and go. I think it comes back to the case point – the cutbacks in Defra have come in already. Have we got any hope of getting anywhere on these expensive things like cattle vaccine? Is the political will there?

Stuart: The cattle vaccine is well down the road. The good thing about the cattle vaccine is that it is just straight BCG, it requires a small dose and in experimental work done at Weybridge it's been shown that it is fairly effective, as effective as you could expect BCG to be, and you can inject the cattle and calves easily. So from that point of view, that work has all been done. But the real stumbling block, and we've known this for years, is with the EU because politically, of course, why should they want Britain to be able to trade cattle potentially infected with TB into Europe? Their stance at the moment as far as I know still is, even though it's not true, that they haven't got a problem with TB in most of Europe. Now we actually know there's a growing problem in France, there's a problem in Spain, there's a problem in Italy, we know about the big problem in Ireland.[173] They've decided to not back vaccination and go down the route of culling, which does seem to be working in Ireland, it's a different situation there. So there's this major political problem of getting cattle vaccination going even though Weybridge have developed this DIVA (differentiating infected from vaccinated animals) test, that's now going to go to field trials – I believe this year it's starting in this country.[174] We have got permission from the EU to do that, which is a big step forward and it's based on gamma interferon tests. This is all going to take years and years, and I think that's the way forward personally really but it's not, as I say, going to be a quick fix, I'm afraid.

Williams: Just a last point on this. It may be a good idea if we just vaccinated the cattle but didn't export them.

Stuart: But there may be other trade effects too.

Montague: Fiona and I left Defra in 2011 so we can only talk about the vaccine policy that Hilary Benn put in when he had the six areas and we were just getting them established by taking them out to farmers meetings,

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[173] For a discussion of bovine TB in Europe, see, for example, Schiller *et al.* (2011).

[174] The DIVA test is being developed to distinguish between vaccinated and naturally infected animals. For a review of vaccination, see Waters *et al.* (2012).

which was quite challenging.[175] One of the early decisions of the new Coalition was to shelve those and just reduce it to the one in Gloucestershire that was already up and running because it was used as a training area for inoculators.[176] We talked earlier about the success of the Badger Panel; we did try to continue that kind of work under the TB Forum, which was chaired by administrators where we had a range of interest groups there.[177] That was unsuccessful, because after we'd been through the agenda of information papers, the opinions were so polarized – there was very strong representation of the wildlife groups through Elaine King mainly,[178] there were similar polarized views coming from the NFU side, so that stakeholder group died a death after we had really explored all the issues in one round of discussions. We then launched a new TB strategy in 2005 after having taken it around for local consultations in 2004.[179] Subsequent to that the advisory groups have been farmer- and vet-focused to reduce the polarized opinions to try and take forward some kind of consensus. I'm sure the only solution to this is when the agriculturalists and the wildlife groups work together on a common, agreed approach because we've already heard, and it was the same under the trial, it was impossible to prosecute the trial due to protestor activity and it's proving pretty well impossible to cull badgers with the level of protestor activity which is now, I would suggest, much worse because it is Gordon's middle-class librarian[180] and not just the activists that we had to deal with as part of the culling trial protestors.

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[175] The Badger Vaccine Deployment Project funded by Defra to vaccinate badgers against bovine TB was originally intended to cover six areas where there was a high incidence of the disease: North West of Stafford, East of Tenbury Wells; North East of Cheltenham; North West of Stroud; West of Tiverton; South East of Tiverton. See Defra (2009).

[176] See the government press release from June 2010 announcing the changes to badger vaccine deployment project online at www.gov.uk/government/news/changes-to-badger-vaccine-deployment-project (accessed 17 February 2015).

[177] The TB Forum ran from 1999 to 2005, with membership comprising representatives from the farming industry, wildlife and animal welfare groups, the veterinary profession, and the ISG. The group met three times a year 'to consider new measures which might be taken to control TB in cattle' and to take into account the views of all the stakeholders in the development of policies. See the archives of the TB Forum at http://webarchive.nationalarchives.gov.uk/20040722232125/http://www.defra.gov.uk/animalh/tb/forum/index.htm (accessed 20 July 2015).

[178] Dr Elaine King represented the National Federation of Badger Groups.

[179] Defra (2005).

[180] See page 66.

Meldrum: Just two points: one is to recap what I said earlier that, during my time in Tolworth when I was CVO, I can assure you we did have mammoth problems with the welfare groups, the badger welfare groups, who were persistently saying to us: 'There is no evidence that badgers are a reservoir of the infection for cattle.' That was an uphill battle. Secondly, I want to come onto the cattle vaccine issue and this is one rare occasion where I disagree with Fiona. I am not at all happy about the idea of vaccinating cattle unless it's very carefully controlled. Our cattle industry is superb, even better than that. We had a problem with a disease called blue tongue; we didn't import live cattle, bovine semen, or embryos from the USA for a very long period of time because of a Hereford bull called Charlie Brown who we were advised was a persistently infected carrier animal for blue tongue.[181] On the basis of evidence from Denver we didn't import any bovine semen and any embryos from the USA and we missed out on that valuable gene pool. Then we had, as we all know, BSE and that was a mega blow for the credibility of the cattle industry in the UK, which is of very high quality. They've got over that now, thankfully we actually did the right things at the right time but it took time.[182] But whatever we do now we must not put our valuable cattle industry at a trading disadvantage. I think the point which was made earlier on was that if you're going to vaccinate, that those cattle have to stay, and it shouldn't be a blanket vaccination policy. It should be very restricted because those cattle that have been vaccinated should not be able to enter trade. If you do that maybe you can get away with it, but I've worked too long in Brussels, it can be a difficult place to work. It was toxic on BSE, I can tell you, the most uncomfortable time in my whole life, when every member state turned against the UK, and I don't want that again. It's very difficult now trying to negotiate with 27 member states and also with the Commission when you are going away from settled policy that has been in place for so long. So I am pretty reserved about this and if we do go down this track and if we do have an effective cattle vaccine, surely the population that's vaccinated must be identified and should not enter international trade. That way you may get away with it. Otherwise it's going to be a very difficult negotiation for the UK.

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[181] Blue tongue is a non-contagious, viral disease of ruminants including sheep, cattle, and goats, transmitted by insects.

[182] Phillips, Bridgeman and Ferguson-Smith (2000).

Stuart: Yes, I do agree with you, Keith, of course, they would be identified and very closely controlled. We got to the stage just before John and I left Defra where we were risking infractions from the EU because we were at such a high level of TB. So eventually we've got to do something – we've had 40 years of trying various things, or more than that actually, and we are where we are now. It's getting worse, that is the problem, isn't it? So I absolutely agree, we'd have to do it in a very, very controlled way and be extremely careful.

Meldrum: Fiona, I totally agree with you about the infraction proceedings, I could have mentioned it earlier. I brought with me a page or two from the Council Directive 64/432, which lays down the criteria for testing for a country to be tuberculosis free.[183] Even in my time frankly we weren't technically TB free and that was another problem that we had with our administrators. Have we got the additional money to enhance the tuberculin testing in the country? Should we have split the country at that time into different sectors? Have TB freedom in Scotland and Wales and Northern England but maybe the rest of England would not have been TB free, and to enhance the tuberculin testing programme that is so expensive? We had BSE on our hands at the time and we were destroying a lot of cattle.

Grant: Are there any general comments that people want to make about this historical experience? I've studied many policy problems over the years, principally in agricultural and environmental policy, I think this is the most intractable I've ever been involved in studying and one of the most difficult and challenging. So I'd be interested in any general concluding remarks that people would like to make on the basis of today's discussion.

McGlone: You didn't really set any ground rules at the start of this gathering, but it has resulted in a very mature discussion over some very prickly issues. There have been some points made, which could have been taken to be personal criticism that weren't, and there are people in the room who were involved in key decisions at key times where there could have been a sense that there was personal criticism of those. The debate has stayed above that, at a level which is very unusual, and it's been I think a very rewarding exercise, and it's not something that I've experienced before. I've been in lots of rooms

[183] Council Directive 64/432/EEC of 26 June 1964 on animal health problems affecting intra-community trade in bovine animals and swine. Defra's *Strategy for achieving Officially Bovine Tuberculosis Free status for England* of April 2014 states: 'For a Member State or region to achieve OTF [Officially bTB Free] status as defined in Council Directive 64/432/EEC, at least 99.9 percent of the herds within it must have been or remained OTF for at least six consecutive years.' (Defra (2014), page 29).

where bovine TB and badgers have been discussed, including some of the forum meetings, and people stayed on their agendas and you knew what was going to happen before you started, and nothing changed during the day. But I think this Witness Seminar has been a very valuable exercise personally.

Williams: Yes, I agree entirely, Gordon, it's been very interesting and I've learnt quite a lot about what's been going on in Defra, what they've been trying to do. It's a shame but they keep it to themselves, they're not very transparent about what they've been doing. I think it might be much better for us all if we knew exactly what was going on.

Stuart: I think that's a bit unfair. I agree absolutely with Gordon's and your comments that this has been very valuable and I think it's partly because we're all getting older and most of us are not actually working in the field any more. It is from my point of view anyway. I think if John and I were still in Defra it might have been a bit different. Actually I could feel my blood pressure going up again when we talked about the reactive cull because we went through a terrible time then. But anyway it has been very interesting. Going back to your point that you don't know what's happening in Defra: we spent weeks and months publishing loads of information and I think it is all there actually, a lot of it, but it might be difficult to access. I don't think there's an air of secrecy any more and that is part of the post-Phillips legacy.[184] I felt that it is very open. But there's so much information that even for us to try to keep up within our own field, was really difficult. So I absolutely appreciate why it would be very difficult for someone a bit removed from it.

Williams: Well, we have to keep putting in Freedom of Information (FoI) requests and so many of them come back just blank, they can't tell us. Gordon will vouch for that, it is very hard to get the facts.

Thomasin-Foster: Does age make one cynical? It probably does. I just wish that we could refer the whole situation to science and keep research leading us forward and stop the politicians meddling.

Meldrum: I know what I am saying because you can't win. In fact, I think there has to be a lot of very detailed internal discussion within any department, on the options. I don't think it would help all that much if every paper that

[184] One of the conclusions of the BSE Inquiry, headed by Lord Phillips of Worth Matravers, was that scientific investigation required a policy of openness and transparency (Phillips, Bridgeman and Ferguson-Smith (2000), volume 1: section 14).

went to a Minister was put in the public domain. Why do I say that? Because my 32 full files on BSE were seized. I got copies back but when you have to go through everything that you've done over a period of time covering every ministerial meeting I'm not sure at the end of the day it really was all that beneficial to analyse every paper that I produced in that way. So I've a balanced view on this: I think the FoI is going too far but you're absolutely right, you should know far more than you have done in the past but how far you go… I think some discussions must be confidential. I have found this a very interesting afternoon – thank you very much. It's a very interesting area and also I am very, very pleased with the level of discussion. No animosity whatsoever. I was a bit fearful we could have some pretty nasty arguments about various aspects of TB and badgers but we haven't had that; it's been a good afternoon from my point of view. Thank you very much.

Meyer: My concluding comment is, you know the thing they say about why the Americans don't understand cricket, it's because at the end of five days there's no result. What baffles me and, I think, the general public is that at the end of 40 years we still don't really understand the problem. I think that's why people are frustrated and annoyed and angry – we don't really understand the process that's going on, let alone have a solution to it.

Grant: Okay, I think on that note we can conclude. I thank you all for coming along today and for your contributions.

Mr Adam Wilkinson: I'd like to say on behalf of the History of Modern Biomedicine Research Group thank you to you all for providing an entertaining and educational afternoon. It's been a great privilege to listen to your reminiscences. I'd like to give particular thanks to our chairman, Professor Wyn Grant, for his excellent chairing of this session.

Appendix 1

Incidents of *M. bovis* infection in non-bovine domestic animals and wild deer in GB confirmed by laboratory culture, 1997–2011[185]

Incidents of *M. bovis* infection in non-bovine domestic animals & wild deer in GB confirmed by laboratory culture

Table 1: Number of infected* animals by year and species

Species	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011**
Farmed Deer	0	1	0	1	0	8	8	0	1	5	1	1	1	1	0
Park Deer	0	0	3	2	0	2	0	2	1	17	4	2	0	6	0
Wild Deer	3	6	7	6	1	3	14	42	31	29	20	31	18	15	9
Domestic Cat	0	2	0	3	0	2	2	6	13	14	15	18	26	23	3
Domestic Dog	0	0	0	0	0	1	0	1	0	0	1	1	3	2	0
Domestic Pig	0	0	0	0	0	1	8	1	12	2	5	10	23	29	5
Alpaca	0	0	0	0	0	0	2	1	0	1	4	13	68	43	4
Llama	0	0	3	0	0	0	1	0	1	8	16	9	0	0	0
Sheep	0	0	0	0	0	1	0	3	2	0	0	1	5	13	8
Goat	0	0	0	0	0	0	0	0	0	0	2	33	0	1	0
Ferret	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
Farmed Wild Boar	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0

Table 2:Total number of animals examined

Species															
Deer (Farmed/ Park & Wild)					53	64	96	110	100	67	63	55	46	27	
Domestic Cat					9	8	39	98	135	103	121	104	86	19	
Dog					3	0	3	0	0	1	16	11	9	3	
Domestic Pig					3	16	9	36	110	66	66	116	340	122	
Alpaca					0	6	2	0	0	4	30	120	151	17	
Llama					0	0	0	4	6	16	15	3	7	1	
Sheep					2	0	11	4	27	0	6	9	39	25	
Goat					0	0	0	0	0	2	44	14	11	1	
Ferret					0	0	0	7	0	0	0	1	3	0	
Farmed Wild Boar					0	0	0	0	4	0	0	2	1	0	

Source: Animal Health and Veterinary Laboratories Agency (AHVLA) TB Culture database

*** Infected = positive for *M.bovis* on culture**

**** Data provided for 2011 is for the period 1 January - 31 March inclusive. All data provided for 2011 are provisional and subject to change as more data becomes availabl**

Note 1: We can only provide data on the number of *M. bovis* isolations from notified suspect clinical and post-mortem cases of TB arising in some non bovine species.
Note 2: Cultures and post mortem examination may not be carried out at the VLA on every animal removed from a herd once TB has been confirmed.
Therefore not all animals removed for TB disease control purposes may have been reported above.
Note 3: The figures represent submissions from individual animals, not premises i.e. several submissions may be from the same premises.
Data to be updated on a quarterly basis - last updated on 15 June 2011.

[185] Taken from www.gov.uk/government/uploads/system/uploads/attachment_data/file/232602/bovinetb-otherspecies-27aug13.xls (Defra 2013) (accessed 15 April 2015). Contains public sector information licensed under the Open Government Licence v3.0. http://www.nationalarchives.gov.uk/doc/open-government-licence/version/3/ (accessed 17 June 2015).

Biographical notes*

Dr Angela Cassidy

BSc MSc PhD (b. 1975) jointly graduated in psychology and zoology from the University of Bristol in 1997, and obtained her PhD in science studies from the University of Edinburgh in 2004. Her doctoral research – a case study of public scientific controversies over evolutionary psychology during the 1990s – was followed by a year as an ESRC Postdoctoral Fellow at the University of Manchester. She spent three years at Leeds University Business School researching engagement and communication of food chain risks, then moved on to the University of East Anglia. At UEA she held a Rural Economy and Land Use fellowship, granted to support her studies of the contemporary public controversy over bovine TB and badger culling in the UK. She then joined the Centre for the History of Science, Technology and Medicine (CHoSTM) at Imperial College in 2011 to research the 'one health' agenda and relationships between human and animal health. In October 2013 she moved with CHoSTM to the Department of History, King's College London, where she is now a Wellcome Trust Research Fellow, and is investigating the history of the UK bovine TB problem between 1965 and 1995.

Mr Michael Clark

BA PGCE FZS (b. 1943) graduated from the University of Middlesex in 1966 with the Queen's Award for Art and Design. He was able to study in Paris, Munich, and Berlin for his thesis in 1965 and contributed to *Private Eye*, *Punch* and various publications in his final academic year, and started work in the Features Department of *The Guardian* newspaper during his last term of the degree. He later gained a PGCE from Leeds University when invited to take up a part-time lecture post after six years in the design and publishing industry. He was a Principal Lecturer, Head of Department, Acting Vice Principal, and finally a Director at North Hertfordshire College. At Hertford Grammar School he mixed three Art and Science 'A' levels as well as Scholarship level Art and Design, and chose Zoology as a good basis for dissection and classification used in a lifetime of field work on wildlife plus over 40 years as the

* Contributors are asked to supply details; other entries are compiled from conventional biographical sources.

volunteer warden of the Herts and Middlesex Wildlife Trust nature reserve at Tewin Orchard. He has been commissioned to write more than five books on wildlife, has illustrated more than 30 other titles, broadcast in both BBC radio and TV programmes, and his bestselling book, *Badgers* (1987, Whittet Books), is in its third edition. His close association with farmers is partly through the smallholding he has managed with his wife Anna Clark for 35 years.

Mr Gareth Davies

MRCVS Dip Bact MRCVS DipBact (b. 1935) was Head of the Epidemiology Unit at the Central Veterinary Laboratory, Weybridge, from 1975 to 1986. After a period at Tolworth he became the Veterinary Epidemiologist at the Veterinary Unit of DG6 (Agriculture) at the European Commission. He has been a consultant to the European Commission and the Food and Agriculture Organization of the United Nations since he retired in 1994, and headed the team that prepared the cost–benefit analysis of vaccination policies for the European Commission in the late 1980s.

Professor Wyn Grant

BA MSc PhD (b. 1947) graduated in Politics from the University of Leicester in 1968, the University of Strathclyde in 1969, and obtained a PhD in Politics from the University of Exeter in 1972. He has worked at the University of Warwick since 1971, becoming Professor of Politics in 1990, and was head of the Department of Politics and International Studies from 1990 to 1997. He has served as Chair and President of the Political Studies Association of the United Kingdom and Vice-President for Europe and Africa of the International Political Science Association. He retired from Warwick in 2012 and is now a part-time professor. He is an Academician of the Academy of Social Sciences. For the past 10 years his research has been in collaboration with life scientists at Warwick, most recently as Deputy Principal Investigator on the Governance of Livestock Diseases as part of the Rural Economy and Land Use Programme.

Ms Emma Jones

BA MSc (b. 1974) is a Research Assistant in the History of Biomedicine Research Group, Queen Mary University of London.

Professor John Krebs, Lord Krebs

Kt FRS FMedSci DSc (Hon) (b. 1945) graduated in Zoology at Pembroke College Oxford in 1966 and gained his DPhil in 1970. After working as Assistant Professor of Ecology at the University of British Columbia and as Lecturer in Zoology at University College of North Wales in Bangor, in 1975 he was appointed Lecturer in Zoology in the Edward Grey Institute of Field Ornithology at the University of Oxford. In 1988 he became a Royal Society Research Professor in the Department of Zoology at Oxford University and in 2005 he was appointed Principal of Jesus College, Oxford. Between 1994 and 1999, he was Chief Executive of the Natural Environment Research Council, and from 2000 to 2005 was Chairman of the UK Food Standards Agency. He chaired the Government review of bovine TB which, in 1997, concluded that badgers were a significant source of the infection in cattle (Independent Scientific Review Group (1997)). He was knighted in 1999 for services to Behavioural Ecology and was elevated to the Peerage in 2007 as a cross bencher. He served as Chairman of the Science and Technology Select Committee from 2010 to 2014 and was Chairman of the UK Science and Technology Honours Committee from 2008 to 2014.

Professor David Macdonald

CBE DPhil DSc FRSE FRGS FSB (b. 1951) received his DPhil from Oxford University in 1977 where he was a research fellow until 1987. In 1986 he founded and became the Director of the Wildlife Conservation Research Unit at Oxford University, the first university-based conservation research unit in Europe, and since 2004 has been Professor of Wildlife Conservation. His research into wildlife conservation and management, focusing on the behavioural ecology of carnivores and mammals, has led to over 600 refereed papers and several authored or edited books. In addition to his academic career he is also known for communicating his research through documentaries and more general books on natural history, twice winning the Natural World Natural History Author of the Year Award (*Running with the Fox* (1987) and *European Mammals* (1995)). His documentaries include the *The Night of the Fox* (1976), a BAFTA finalist for Best Documentary of the Year, and the BBC1 series *The Velvet Claw: A natural history of the carnivores* (1992). He has won several awards,

including the Dawkins Prize for Conservation and Animal Welfare in 2004 and the Gold Medal of the Mammal Society of Great Britain in 2007.

Dr Gordon McGlone

OBE BSc MBA PhD MCIEEM CEnv (b. 1951) graduated in Botany with Zoology from the University of Wales, University College Swansea (UCS), in 1972. He went on to carry out PhD research into the accumulation and toxicity of heavy metals to marine phytoplankton. He worked in the Botany Department of UCS as Research Demonstrator in Environmental Botany until 1979 when he took up the appointment of Executive and Conservation Officer with the Gloucestershire Trust for Nature Conservation. He developed the scope and expertise of the Trust, becoming the first CEO of what is now the Gloucestershire Wildlife Trust (GWT). He became involved with the subject of badgers and bovine TB from 1979, becoming a member of the Minister's Advisory Panel and the spokesperson for the Wildlife Trusts, giving evidence to select committee in 1999. He left the GWT in January 2012 to set up a consultancy specializing in nature and sustainability. He continues to advise the Wildlife Trusts on badgers and bovine TB at a national level. He is currently an Associate of the School of Management, University of Bath, where he completed an MBA in 2003.

Mr Keith Meldrum

CB BVM&S MRCVS DVSM HonFRSH (b. 1937) was Chief Veterinary Officer at MAFF from 1988. He worked his way up through the ranks of the State Veterinary Service, starting in the field in Oxfordshire as a young veterinary officer, becoming Director of the Veterinary Field Service in 1986 before being appointed as CVO for the UK. Latterly as CVO he was involved with the intricacies and difficulties in developing a strategy to deal with tuberculosis in cattle and badgers in the face of an ever-worsening disease situation. He also led the Government's response to the emergence and spread of bovine spongiform encephalopathy (BSE) and was the lead Government witness to the Public Inquiry into BSE after his retirement. The report of that inquiry and his involvement with it can be found at http://webarchive.nationalarchives.gov.uk/20060715141954/bseinquiry.gov.uk/ (accessed 12 May 2015).

Dr Richard Meyer

PhD PGCE (b. 1946) began his career in 1969 at the Wildfowl Trust, Slimbridge with Peter Scott, writing and illustrating his first book *Wildfowl in Captivity* (1972, Gifford). He worked in zoology and ecology in Britain and abroad, including the Institute of Terrestrial Ecology at Merlewood (Cumbria) and Winged World (Morecambe); curated small mammals and birds at Cotswold Wildlife Park and Padstow (Cornwall), and wrote and illustrated more than 100 articles and papers, and 12 books, written under the name Richard Mark Martin, including *Mammals of the Seas* (1977, Elsevier, Putnams & Hutchinson), *Cage & Aviary Birds* (1980, Collins), *The Dictionary of Aviculture* (1983, Batsford), and *First Aid and Care of Wildlife* (1984, David & Charles). While establishing a field centre in North Cornwall, he became involved in badgers and bTB: chairing Cornwall's Badger Group, working for WWF, and serving on the Consultative Panel; then writing *The Fate of the Badger* (1986, Batsford). As a MIBiol, he completed his PhD in 1990 at Glasgow University (Feeding Ecology of the Chough in West Wales and its Re-establishment in England), and in 1991 he qualified as a primary teacher at UWE Bristol. He worked as a schools' liaison officer for the RSPCA, and ran Cannington College Outcentre in Paignton Zoo (1998). He now writes, paints, and undertakes freelance work in Devon.

Mr John Montague

BVSc MRCVS (b. 1952) graduated in Veterinary Science from University of Bristol in 1975. He worked in veterinary practice for 12 years and from 1979 in the North Cornwall/North Devon TB hotspot area. On leaving practice in 1987, he joined MAFF as a veterinary officer at Cardiff in the South Wales Division with lead roles in meat hygiene and then bovine TB where he was responsible for managing the re-emergence of TB in South East Wales after a period of 35 years. In 1997 he took up TB veterinary adviser roles to both the Cardiff and Westminster governments. In 2000 he was appointed National Trial Manager to lead the Defra wildlife units at Stroud and Truro in the delivery of the Randomised Badger Culling Trial (RBCT). On completion of the trial fieldwork in 2006 he became Head of Veterinary Advice in London before retiring from Defra in 2011, since when he has been a part-time consultant on bovine tuberculosis.

Miss Eunice Overend

(b. *c.*1919) taught biology at a school in Somerset. After the war she worked with the ornithologist Peter Scott as the first curator of the Severn Wildfowl Trust at Slimbridge. With a love of wildlife since childhood, she studied the social structure of badger communities, lived with badgers in a caravan in Wiltshire, and actively opposed the Government's badger culls. She argued that badgers were not responsible for passing bTB to cattle, and pushed for the vaccine development. See Dunn (1993).

Ms Fiona Stuart

MSc, BVet Med, MRCVS (b. 1955) graduated with distinction in veterinary medicine from the University of London in 1978, winning the First Fitzwygram prize, and obtained an MSc in medical microbiology in 1984 at the University of Surrey. She worked as a resident house surgeon at the Royal Veterinary College, University of London and then as a locum in small animal practice in Surrey (1978–1979). She became a Research Officer and subsequently Senior Research Officer at the Central Veterinary Laboratory, Weybridge, working initially on brucellosis and *Campylobacter* and then on bovine tuberculosis (1979–1990). She moved to Zimbabwe and worked for the Crocodile Farmers' Association (1991–1992), doing locums in small animal practice, training horses, and running an Arabian Stud (1990–1999) as well as working as a senior sales negotiator for Dandaro Retirement Village (1994–1998). She returned to the UK in 1999 as Senior Liaison Officer in the Chief Scientist's Group, MAFF, to set up the new TB research programme (1999–2003), followed by a year in Wellington, New Zealand working as Principal Scientist in Biosecurity, MAF (2004), returning to the UK to be Head of TB Science in the TB policy group at Defra HQ in Westminster (2005–2011). She also worked part time as Deputy Programme Manager, TB Department, CVL (2007–2008). She retired in 2011 and now runs a smallholding in Surrey, trains horses, and volunteers for Carriage Driving for the Disabled.

Mr Mark Thomasin-Foster

CBE BSc DL FRAgS (b. 1943) was educated at Wye College University of London. After a year in the Department of Agriculture in Australia (1966–1967) he returned to farm in Essex. He was instrumental at the beginnings of the Farming and Wildlife Advisory Group, becoming National Chairman in the late 1980s. Appointments have included Council of English

Nature (1990–2000), UK Round Table on Sustainable Development, the Ministry of Agriculture's Environment Group on Research and Development, Chairmanship of the Minister's Panel on Badgers and bTB (1987–1997), UK Woodland Assurance Standard Board, Forestry Commission's Advisory Panel, LEAF (Linking Environment and Farming) and Confederation of European Agriculture Country Land and Business Association (CLA) appointments, Executive Board, chairmanships of Environment and Water and Agriculture and Rural Economy committees, and as CLA European Vice President. In July 2004 he was elected the President of the European Landowners' Organization (ELO) Brussels, the Federation of the 68 national landowner organizations across the EU member states. He retired in June 2010 but was elected their Honorary President. He is a Deputy Lieutenant for Essex, was created a CBE in 1992, was awarded Fellowship of the Royal Agricultural Societies in 1993, and was High Sheriff of the County of Essex in 2003. He now lives and has a small hill farm on Exmoor where he sits on various advisory groups for the Exmoor National Park but continues his active arable farming in Essex.

Professor Keir Waddington

BA MA PhD (b. 1970) graduated in history from the University of East Anglia in 1991, and obtained his PhD in history from University College London in 1995. His doctoral research – an examination of charity and hospital finance in Victorian London – was followed by 15 months at the Wellcome Centre for the History of Medicine, University College London, working with Roy Porter on the *History of Bethlem* (1999). He spent three years at Barts and the London School of Medicine and Dentistry researching medical education and the history of Barts Medical School from 1123 to 1995; then moved on to Cardiff University. At Cardiff, he initially held a university fellowship to undertake research on bovine TB and diseased meat in the nineteenth century before moving on to a permanent post as well as establishing the Collaborative Interdisciplinary Study of Science, Medicine and the Imagination research group with Martin Willis. At Cardiff he has continued to research diseased meat and health and has worked on twentieth-century comparisons between bTB and BSE, and is now investigating rural public health in Victorian and Edwardian Wales.

Mr Adam Wilkinson

BSc (b. 1977) is Project Manager of the History of Biomedicine Research Group, Queen Mary University of London.

Mr David Williams

CIEEM (b. 1940) has studied all aspects of natural history since childhood, and has had a particular interest in badgers since 1984, when he was a founder member of the West Surrey Badger Group. Since the inception of the Protection of Badgers Act in 1992, he has worked as a badger consultant on a professional basis. He has worked for local and county councils, building companies, environment consultant agencies, sand extraction etc., and has worked with Surrey and Metropolitan police, and given training to both forces. He has been an expert witness for the police and the RSPCA, and has completed fieldwork with Professor Stephen Harris of Bristol University in Zoological Studies, and studied all published scientific work and project reports on badgers. He was appointed Mammal Project Officer for the Surrey Wildlife Trust in 2003, working on many mammal projects and protected species, including research projects on harvest mice and dormice. He has been chairman of the Badger Trust since 2005. He is a qualified trainer on badger ecology and survey techniques for the Mammal Society and Chartered Institute of Environmental and Ecological Management. Since 1984, he has followed closely the problem of bovine TB and badgers.

Professor Solly Zuckerman, Lord Zuckerman

OM KCB Kt MD DSc MRCS FRCP FRS FIBiol HonFRCS HonFPS (1904–1993) studied at the University of Cape Town and then moved to London in 1925. After appointments as Anatomical Research Fellow at the Zoological Society of London and Demonstrator of Anatomy at UCL and a period at Yale, in 1934 he was appointed demonstrator and Lecturer in the Department of Anatomy at Oxford University. After the war he took up his deferred post as Sands Cox Professor of Anatomy at Birmingham University (Professor Emeritus from 1968) and then from 1969 to 1973 was Professor-at-large at the new University of East Anglia, with responsibilities for the School of Biological Sciences. During the war he was scientific adviser to Combined Operations Headquarters, where he established a reputation as an authority on defence and weaponry. He served on numerous government committees and in 1960 was

appointed Chief Scientific Adviser to the Ministry of Defence, then in 1964 Chief Scientific Officer to the Government. On his retirement in 1971, he was created a life peer. His links with the Zoological Society of London remained all his life; he was Honorary Secretary from 1955 to 1977 and President from 1977 to 1984. See Krohn (1995).

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