Use Of Evidence In Policy Making and Its Relevance To The Management Of bTB In The UK

Boyd, I., Chief Scientific Adviser, Defra, Nobel House, 17 Smith Square, London, SW1P 3JR

Animal disease control requires the development and implementation of policies that are built upon evidence concerning risks involving pathways of transmission between infectious and susceptible individuals. It is possible to distinguish between strategic evidence and tactical evidence. The former establishes the background to control strategies whereas the latter support near-real-time intervention. In the UK, bTB strategic evidence comes from knowledge of the Randomised Badger Culling Trial, TB national statistics and a variety of other studies pointing to the epidemiology of the disease. It has led to a national strategy that advocates (a) a focus on controlling the hazard; (b) ensuring that future interventions are designed to minimise risks and are applied proportionately to the regional/local circumstances; and (c) ensuring those who are responsible for managing behaviours that change risks are aware of their responsibilities and incentivised to deliver effective disease control. Delivery of this strategy relies upon tactical evidence, mainly from tuberculin testing, but there is increasing use of a broader set of evidence measurements to build a risk-based approach to disease management.

Managing Challenges To Disease Eradication: The Example Of Rinderpest

Roeder, P., Taurus Animal Health, Holly Hedge Cottage, Spats Lane, Headley Down, Bordon, Hampshire, GU35 8SY, UK

For millennia the contagious viral disease rinderpest, or cattle plague as it was known in English, devastated livelihoods based on cattle rearing throughout Asia, Europe and, latterly, Africa. In the 19th and 20th centuries its control was the pre-occupation of veterinarians and national veterinary services. With the development of safe and efficacious cell culture vaccines in the 1950s and 1960s it became recognised that regional elimination and even global eradication was feasible to contemplate. Thereafter, eradication was achieved by 50 years of concerted effort with a final thrust led by the Food and Agriculture Organization of the United Nations – the Global Rinderpest Eradication Programme. Many challenges had to be overcome during the process. These can be considered as falling into two categories. Firstly, and in many ways the easiest to deal with, were issues relating to technical matters. These included the development of robust diagnostic tests, fit-for-purpose to be transferred to developing countries to be used in diagnostic confirmation, surveillance and verification of disease freedom. In addition refinement of vaccines to ensure an adequate supply of quality-assured, thermostable vaccines overcame constraints imposed by the need for cold chain in remote areas and accessibility to insecure areas. Of fundamental importance was developing a sound epidemiological understanding to identify transmission chains and other factors in virus persistence. Once these were in place it became feasible to generate and implement sound science-based control strategies. In doing so the programme encountered a second set of challenges – those relating to organisational and political elements. These ranged from the difficulty of maintaining a focus on rinderpest eradication, sustaining interest and political will, lack of adequate human and fiscal resources, leadership, coordination and management and delivery systems for vaccination appropriate for different farming systems. These, and the means by which they were overcome, will be described.

Understanding and managing bTB risk: perspectives from Ireland

More, S., UCD School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland

The presentation of bovine tuberculosis (bTB) in Ireland has a number of consistent features, including spatial clustering and local persistence. There has been an intensive programme of scientific work for
An improved understanding of vaccine-induced protection against bovine tuberculosis (TB), development of DIVA tests to differentiate *Mycobacterium bovis*-infected from BCG-vaccinated cattle and formulation of oral bait vaccine for wildlife have rekindled interest in use of TB vaccines for cattle and wildlife. Vaccination could have particular application in countries where bovine TB control programs are not affordable or are less effective when TB is maintained in wildlife reservoirs of infection. In recent years, studies have moved from the development and testing of vaccines in small animal models and assessing efficacy by experimental challenge in target animals to evaluation of vaccines in field trials. The human TB vaccine, BCG has been shown to induce a reduction in lesion scores in *M. bovis* experimental challenge studies and reduced infection in field trials in both cattle and wildlife. The major caveats concerning the use of BCG in cattle are that protection is not complete and a proportion of vaccinated animals respond positively in the tuberculin skin test. In cattle, valuable information has recently been obtained for BCG vaccine on the duration of immunity, effect of revaccination, protection against natural exposure to *M. bovis* and use of DIVA tests. Using mycobacterial antigens which are expressed by virulent *M. bovis* but not by BCG, both blood-based and skin tests have been developed to differentiate infected from vaccinated animals. Research to identify effective TB vaccines for cattle has greatly benefited by leveraging from human TB vaccine studies and a range of new types of vaccines have recently been evaluated in cattle. To date, no sub-unit TB vaccines have induced improved protection in cattle compared to that for BCG, but prime-boost combinations of BCG with DNA, protein or virus-vectored vaccines have induced better protection than BCG vaccine alone. From a number of these studies, an improved understanding of the protective immune response has been obtained and the identification of immune correlates of protection such as induction of IL-17, IL-22 and central memory responses should help identify improved vaccine candidates.

Development of an oral bait BCG formulation has demonstrated the practicality of delivering TB vaccines to wildlife. Systems have been developed to assess TB vaccine efficacy by the experimental challenge of the wildlife species, serving as the maintenance hosts for *M. bovis* infection. Bait attractants for wildlife species have been devised and bait uptake studies have been undertaken. Oral BCG preparations have induced protection against experimental challenge of *M. bovis* in possums, badgers, wild boar and white-tailed deer and against natural exposure to *M. bovis* in possums. Encouragingly, BCG vaccine that only served to decrease lesion severity and bacterial counts in experimental challenge trials in possums appeared to protect them against infection following natural exposure to *M. bovis*. Trials are in progress to evaluate oral and parenteral BCG vaccines in badgers against natural exposure to *M. bovis*. Recent progress in TB vaccine development has provided much impetus for their future use.
Routine Whole Genome Sequencing Of Bovine Tuberculosis; What WGS Of bTB Can Do For You
Smith N.H., AHVLA Weybridge, Surrey KT15 3NB, UK

The development of ‘desktop’ Whole Genome Sequencing (WGS) machines such as the Illumina MiSeq have made WGS for routine genotype and phylogenetic analysis a viable proposition. The key breakthrough was establishing that high-quality WGS could be obtained from ‘heat-killed cells’ without any further purification of bacterial chromosomal DNA. These two developments mean that routine WGS for species identification, genotyping, phylogenetic analysis and epidemiology is now an economically feasible replacement for standard (spoligotype and/or VNTR) genotyping pipelines dealing with up to 6000 bTB isolates a year.

Using controls and a series of targeted case studies based on over 500 isolates I will show how WGS data can give greater insights into specific epidemiological questions while at the same time maintaining the standard genotyping nomenclature that our customers have come to expect in GB. The requirements for a customer driven ‘commercial’ WGS pipeline will be described and contrasted with a simple ‘research’ pipeline. I shall also outline plans for a database of all bTB WGS that will allow the data to be freely available to researchers from all over the world (possibly associated with www. Mbovis.org).

The WGS diversity within strains of M. microti will be compared with M. bovis, a strain of M. microti without a spoligotype pattern will be described, a WGS phylogeny of the animal-adapted, RD9 deleted lineage of the MTB complex will be presented and the use of ‘molecular clocks’ discussed.

Molecular Epidemiology Of Bovine Tuberculosis In Cameroon
Franklyn, N., Laboratory for Emerging Infectious Diseases, Faculty of Science, University of Buea, Buea, Cameroon

Bovine tuberculosis (bTB) is an important global disease of livestock and in particular cattle. However, in many low and middle income countries little is known about its epidemiology, the strains circulating, the impact on livestock production or the risks to human health, particularly in populations with a high HIV burden.

Over 2012-2013 we conducted abattoir studies on bTB in cattle in 4 sites, Bamenda, Ngaoundere, Garoua and Maroua, across Cameroon. 2,092 slaughtered cattle were screened for bTB by meat inspection and in 2 sites by bovigam® and a commercial ELISA (IDEXX bTB antibody). Up to 3 lesions per animal were sampled plus a random sample of ~10% of non-infected animals. Samples were cultured on LJ slopes and by liquid culture (BACTEC). Positive samples were typed to species (Haines) and then all M. bovis isolates spoligotyped and MIRU/VNTR typed.

This paper will present the results of the abattoir study. Provisional estimates are of a prevalences of lesions ranging from ~4% to ~20% of cattle slaughtered at the different abattoirs. Both M. bovis and M. tuberculosis were isolated from lesions while a number of non-tubercular mycobacterium were isolated from gross normal animals. We will present the molecular epidemiological data and spatial diversity of strains from Cameroon and compare typing results to bovigam and post mortem results.

An Epidemiological Study of Risk Factors that Affect the Rate of Expansion of the Area Affected by Endemic Bovine Tuberculosis
Brunton, L.A.¹, Alexander, N.², Wint, W.², Ashton, A.¹, Goodchild, A.¹, Broughan, J.¹
¹Animal Health and Veterinary Laboratories Agency, United Kingdom.
²Environment Research Group Oxford, United Kingdom
Introduction
An understanding of the factors that affect the spread of endemic bovine tuberculosis (bTB) is critical for the development of measures to stop and reverse this spread. The rate of expansion of the endemic area varies geographically in England and Wales, so understanding what factors are important at a local level could guide the implementation of tailored local controls.

Materials and methods
A novel approach was developed to map the expansion of the endemic area between 2001 and 2012 and calculate the rate of expansion. The influences of a range of environmental, farm management and landscape risk factors on the speed of the spread of the endemic front were examined using classical linear regression models and geographically weighted regression to account for the fact that the variables of interest are not fixed over space.

Results
A great deal of spatial variation was observed in the most influential risk factors associated with the spread of endemic bTB. The direction of the associations varied geographically for all of the variables, indicating that in some areas a variable might be associated with a reduction in the rate of spread whilst in others it might be associated with an increase in the rate of spread.

Discussion/Conclusion
A complex pattern emerges when the spread of bTB is modelled at a regional level. This complex picture should be investigated further to help understand how policies could be tailored to tackle bTB at a regional level.

Enhanced Understanding Of Pathogenesis and Epidemiology Through Use Of A “Forensic” Post Mortem Examination
Corner, L.A.L.1, Gormley, E.1, Ni Bhuachalla, D.1, Murphy, D.2,
1School of Veterinary Medicine, University College Dublin, Republic of Ireland.
2Department of Agriculture, Food and the Marine, Regional veterinary Laboratory, Athlone, Co. Longford, Republic of Ireland

Keywords
badger, pathogenesis, epidemiology

Abstract
The design of tuberculosis control strategies in animals, including vaccination, is contingent on our detailed understanding of the pathogenesis and the epidemiology of the disease in naturally infected animals. Unfortunately, for most species in which infection with Mycobacterium bovis is prevalent, our knowledge of the pathogenesis is limited to a description of the distribution of visible lesions, and occasionally histological lesions. The constraints to a thorough post mortem examination include the unavailability of naturally diseased animals, the shear mass of the animal, e.g. deer and cattle, and the time taken and laboratory resources that are necessary. However, in smaller animals it is possible to undertake a thorough gross post mortem examination and, with sufficient resources, also determine the distribution of histological lesions and bacterial infection. We have undertaken such a study in naturally infected badgers where we determined that the animals with gross lesions and those that were excreting M. bovis significantly underestimated the true prevalence of disease in the population, and that gross lesions were a poor guide to the distribution of histological lesions and culture positive tissues. Strain typing of multiple
isolates from individual animals demonstrated that badgers may be infected concurrently with multiple strains. The deeper understanding of the pathogenesis of *M. bovis* infection in badgers, and a better means to estimate prevalence of infection, routes of transmission and infection, will lead to more efficient ways incorporate vaccination into TB control in badgers. The implications for our understanding of Tb in other species will be discussed.

**A Longitudinal Model Of Bovine Tuberculosis Transmission In Great Britain**

McKinley, T.J.\(^1\), Conlan, A.J.K.\(^1\), Pollock, E.B.\(^1\), Mitchell, A.\(^2\), De Angelis, D.\(^3\), Roberts, G.O.\(^4\), Wood, J.L.N.\(^1\),

\(^1\)University of Cambridge, Disease Dynamics Unit, Department of Veterinary Medicine, Cambridge, UK
\(^2\)AHVLA, Weybridge, UK
\(^3\)MRC Biostatistics Unit, Institute of Public Health, Cambridge, UK
\(^4\)University of Warwick, CRiSM, Department of Statistics, Coventry, UK

**Introduction**

Britain spends over £100 million per year in surveillance and compensation for bTB, resulting in costly movement and trade restrictions for farmers. Despite intensive surveillance, considerable uncertainty remains surrounding the true distribution of infection in cattle and wildlife populations. Herds are monitored through slaughterhouse surveillance and regular skin testing, and the frequency of testing for individual herds is based on localised incidence, which acts as a proxy for the risk of infection, but does not account for explicit herd-level characteristics or cattle movements. Surveillance tests are also imperfect, with the lack of a gold-standard diagnostic test making it difficult to estimate levels of unobserved infection. Finally, the lack of detailed information about environmental and wildlife reservoirs makes it challenging to untangle the relative contributions of cattle-to-cattle and spatially localised transmission from other sources.

**Methods**

We address these issues by fitting a Bayesian hierarchical statistical model at the individual animal-level to testing and incidence data from 2003–2011. This approach models the hidden transmission process through the use of latent variables, and is fitted using reversible-jump Markov chain Monte Carlo. We estimate the levels of heterogeneity in the risk of infection from cattle-to-cattle transmission compared to introduction from other sources. Our approach potentially allows us to estimate the true efficacies of surveillance tests, as well as the degree of underlying infection, alongside spatially-explicit estimates for the background risk-of-infection from environmental reservoirs. Moreover, it provides a rigorous inferential framework within which to benchmark the predictive ability of alternative transmission models.

**Host Richness Increases Tuberculosis Disease Risk**

Vicente, J., Barasona J.A., Gortázar, C., de la Fuente, J.,

SaBio Ciudad Real: Epidemiología y control de enfermedades, Genómica y Proteómica, IREC - Instituto de Investigación en Recursos Cinegéticos, Ronda de Toledo s/n, 13071 Ciudad Real, Spain

Current scientific debate addresses whether species richness in natural communities may negatively moderate pathogen transmission and disease outcome or to the contrary, if disease emergence benefits from more diverse community assemblages. The outcome may not exclusively depend on patterns of host species biodiversity but may depend on the specific composition of reservoir hosts and vectors, and their ecology. Host-pathogen interactions have shaped variations in parasite virulence, transmissibility and specificity, and the importance of factors related to host exposure or to life history trade-offs are expected
to vary. Herein, we demonstrate that ungulate host species richness correlates with increased community competence to maintain and transmit tuberculosis (TB). Therefore, we must consider natural variations in life histories of pathogens and host communities to characterise the impact of biodiversity conservation on health of diverse assemblages of human and animal communities.


Salvador, L.\textsuperscript{1}, Bessell, P.R.\textsuperscript{2}, Enright, J.\textsuperscript{1}, Kao, R.R.\textsuperscript{1},
\textsuperscript{1}Institute of Biodiversity, Animal Health and Comparative Medicine, College of Medical Veterinary and Life Sciences, University of Glasgow, Glasgow, UK
\textsuperscript{2}The Roslin Institute, The University of Edinburgh, Easter Bush, Midlothian, EH25 9RG, UK

Keywords
epidemiology, \textit{M. bovis}, cattle, surveillance system

Introduction
A central question in disease surveillance is how to design more effective and efficient methods to either improve our ability to detect disease, make cost savings or do both. Currently, in Great Britain, the surveillance system for bovine Tuberculosis considers 1 and 4 year testing regimes depending on the prevalence of the disease and the geographical area. However, balancing the risks associated with failing to identify infection when it is present, with the resources and costs associated with the different components of the surveillance regime remains a challenge.

Materials and methods
In this study, we used statistical methods and machine learning techniques on Cattle Trace System (CTS) and VetNet data, to identify risk factors that can better predict bovine Tuberculosis (bTB) breakdowns in 4-year testing areas in England and in Scotland.

Results
Our results show that 1) by incorporating bTB risk factors in our analyses, our prediction of breakdowns was improved in the two areas of study; 2) some risk factors (\textit{e.g.} movements from risky farms) have more impact than others in the prediction of breakdowns, mainly in Scotland; and 3) in general, we have a better prediction of herds at risk in 4-year testing areas in England than in Scotland.

Discussion/Conclusion
Our analyses provide a basis for a better understanding of which risk factors are responsible for bTB breakdowns in different areas with a similar testing regime, and suggest that the differences between the two areas may be important to establish better cost-effective means of controlling the spread of bTB.

Tuberculosis In Domestic Pigs In Great Britain 2007-2011

Bailey, S.S.\textsuperscript{1}, Crawshaw, T.R.\textsuperscript{2}, Smith, N.H.\textsuperscript{3}, Palgrave, C.J.\textsuperscript{1},
\textsuperscript{1}Veterinary Pathology, School of Veterinary Sciences, University of Bristol, Langford House, Langford, Bristol, BS40 5DU, UK
\textsuperscript{2}Animal Health and Veterinary Laboratories Agency (Starcross), Staplake Mount, Starcross, Exeter, Devon, EX6 8PE, UK
\textsuperscript{3}Animal Health and Veterinary Laboratories Agency (Weybridge), Woodham Lane, New Haw, Addlestone, Surrey, KT15 3NB, UK
Keywords
Bovine tuberculosis (TB); *Mycobacterium bovis*; Pig (*Sus scrofa*); Badger (*Meles meles*); Wildlife

Introduction
*Mycobacterium bovis* infects a wide range of wild and domestic mammals. This study examines the epidemiology of *M. bovis* in pigs and correlates it with cattle and badgers.

Materials and Methods
TB-suspect lesions identified in pigs at British abattoirs between 2007 and 2011 were sampled and mycobacterial isolates identified by culture and spoligo-/VNTR-typing. The geographical distribution of *M. bovis* and *M. avium* cases was determined; *M. bovis* isolates were also mapped against the equivalent genotypes in cattle and badgers. Data regarding the age/number of affected pigs, herd size, anatomical location of lesions and opportunity for contact with wildlife or cattle were also collected.

Results
Nationwide, TB lesions are as likely to be caused by *M. avium* (11.7% of TB-suspect lesions) as *M. bovis* (12.8%). However, in the South-West (SW) and West Midlands (WM) regions, *M. bovis* predominates (86%). Although similar genotypes occur in cattle and pigs, opportunities for direct contact between these species are rarely observed. Mapping data indicates that some strains in pigs may correlate better with those present in badgers. *M. bovis* is more commonly seen on farms where pigs are kept outdoors or wildlife may have access to pens (77.4%).

Conclusion
*M. bovis* is the major cause of TB-suspect lesions in pigs in the SW and WM regions. Breakdowns are most common on farms with lower biosecurity; furthermore some *M. bovis* genotypes correlate better with badger data, than cattle. Pigs may therefore represent a useful sentinel for the disease in wildlife.
BCG-efficacy Assessment In A Goat Model Of Tuberculosis With Quantitative Evaluation Of Lung Lesions and Bacterial Load In Respiratory Lymph Nodes

Pérez de Val, B., López-Soria, S., Vidal, E., Nofrarías, M., Martín, M., Cervera, Z., Domingo, M., Centre de Recerca en Sanitat Animal (CReSA) (UAB-IRTA), Campus de Bellaterra, edifici CReSA, 08193 Bellaterra, Barcelona

Keywords
- goats
- animal models
- vaccines
- BCG

Introduction
Domestic goats are natural host of *Mycobacterium caprae* and *M. bovis*. BCG vaccine efficacy has been already evaluated in cattle and in a number of tuberculosis (TB) wild hosts such as badgers, deer, possums or wild boar. We have developed a goat experimental tuberculosis model, and have used it for assessment of BCG vaccination, with or without antigenic adenoviral boosting, to protect against a *M. caprae* challenge.

Material and methods
Vaccinated (N=11) and unvaccinated (N=11) goats were anesthetised and challenged with ~1.5×10³ CFU of *M. caprae* through the endobronchial route, which represents a low challenge dose by a natural route of infection. After challenge, goats were weighed weekly. Whole blood antigen-specific IFN-γ responses were monitored throughout the experiment (Bovigam®, Prionics). All goats were euthanised at 13 weeks post-challenge. Pulmonary lymph nodes were carefully removed for bacteriological count. A quantitative assessment of lung pathology was applied: whole lungs were fixed by flushing formalin into the trachea. After complete fixation lungs were scanned with a multi-detector computed tomography (CT) system (Brillance CT 64-channel, Philips Medical Systems).

Results
TB lesions in lungs, expressed as percentage of lung volume, and bacterial counts in respiratory lymph nodes were lower in vaccinated goats. Quantitative pathological and microbiological data were combined with clinical parameters, as weight gain, and immunological parameters as IFN-γ responses to PPD or ESAT-6/CFP-10 peptide cocktail.

Discussion/Conclusion
The goat model offers a great potential for assessment TB vaccines either experimentally or in field trials.

Use Of Simultaneous BCG and Recombinant Adenovirus Vaccination To Protect Against *Mycobacterium bovis* (*M. bovis*) Infection In Cattle

Dean, G.S.¹, Clifford, D.¹, Vordermeier, M.¹, Xiang, Z.², Beverley, P.³, Tchilian, E.³, Villarreal-Ramos, B.¹,

¹TB Research Group, AHVLA Weybridge, Woodham Lane, New Haw, KT15 3NB, Surrey, UK
²McMaster Immunology Research Centre, Department of Pathology and Molecular Medicine, McMaster University, Hamilton, Ontario, Canada
³University of Oxford, Nuffield Department of Medicine, The Peter Medawar Building for Pathogen Research, South Parks Road, Oxford OX1 3SY, UK

Five groups of ten Holstein calves aged approximately 6 months were immunised, or not, with BCG via the endobronchial (e.b.) and/or subcutaneous (s.c.) routes. One additional group received BCG s.c. followed by recombinant adenovirus expressing Ag85A (Ad5-85A) e.b.. Immune responses in peripheral blood were monitored regularly and the animals were challenged with an infectious dose of ca. 2000 cfu *M. bovis*.
AF2122/97 12 weeks after immunisation. Twelve weeks after infection, detailed post mortem examinations were carried out on all of the animals and samples taken for culture and histopathology. There was a trend towards reduced pathology scores in dually vaccinated animals compared to animals that received a single dose of BCG via either route. Further, histopathological analysis showed a marked decrease in development of advanced granulomata in both dual-vaccinated groups compared with animals vaccinated by only one route. Also, administration of e.b. Ad5-85A in conjunction with s.c. BCG significantly reduced incidence of Stage I and II granulomata compared with BCG/BCG. All four vaccination regimes reduced pathology scores and granuloma development compared with the naïve controls. Thus, combining of local and systemic vaccination was able to limit the development of pathology and thus potentially prevent progress of the disease to an infectious state.

**Paratuberculosis Vaccination Confers Partial Protection Against M. bovis Infection In Cattle**

Juste, R.A.¹, Minguijón, E.¹, Urkitza, A.², Geijo, M.V.¹, Sevilla, I.A.¹, Elgezabal, N.¹, Arrazuria, R.¹, Vázquez, P.¹, Garrido, J.M.¹,

¹Animal Health Department, NEIKER-Tecnalia, Bizkaia, Spain
²Veterinary Surgeon, Bizkaia, Spain
³Department of Bovine Tuberculosis, AHVLA, Surrey, UK

Keywords

cattle, paratuberculosis, MAP vaccine, TB protection

Paratuberculosis (PTB) vaccination in goats seems to provide a certain level of protection against tuberculosis. In order to know whether or not this also occurred in cattle, 2-3 month-old calves in a feedlot were tested with standard IFN-γ release assay (IGRA) and vaccinated with 1ml of an inactivated PTB vaccine (SILIRUM®). One month after moving them to bio-containment facilities, 5 vaccinated and 5 non-vaccinated animals were infected with 105 cfu of *M. bovis* in 2ml of PBS by the intratracheal route resulting in the following groups: PTB vaccinated-*M. bovis* infected (VI), only PTB vaccinated (VNI) and only *M. bovis* infected (INV). Three months later the animals were killed and necropsied. Gross lesions location and dimensions were recorded and evaluated with a standard subjective score and with an estimate of the lesion volume. Ten tissue samples from each individual organs and lymph nodes were submitted to *M. bovis* isolation in an automated culture system. All VNI were negative, both pathologically and microbiologically. All the animals of both infected groups showed lesions and yielded *M. bovis*, but INV yielded higher lesion scores/volume (19.8/365450 vs 14.4/ 21933) and rates of isolation (88.2% vs 63.8%) than VI. These figures represented reductions of up to 94% in lesion volume, but were more consistent between pathology and microbiology at around the 30% level.

Project funded by MINECO (AGL2008-05820-C02-1).

**Vaccination Of Badgers Against Bovine Tuberculosis**

Lesellier, S.¹, Anderson, P.¹, Ashford, R.¹, Dalley, D.², Dave, D.³, Kilcoyne, P.¹, Gowtage, S.¹, Palmer, S.¹, Wheeler, P.¹, Williams, G.A.¹, Salguero, J.¹, Nunez, A.¹, Crawshaw, T.², Corner, L.³, Spyvée, P.⁵, Rogers, F.⁵, Chambers, M.¹,²,³

¹Animal Health and Veterinary Laboratories Agency (AHVLA), Weybridge, Woodham Lane, New Haw, KT15 3NB, UK
²AHVLA Starcross, Staplake Mount, Starcross, Exeter, Devon EX6 8PE
³Veterinary Science Centre, Belfield, Dublin 4, Ireland
⁴School of Veterinary Medicine, Faculty of Health and Medical Sciences, University of Surrey, Guildford, Surrey, GU2 7T, UK
⁵National Wildlife Management Centre (NWMC), Animal Health and Veterinary Laboratories Agency, Woodchester Park, Gloucestershire, UK
The control of Mycobacterium bovis (M. bovis) infection in cattle herds (bovine TB) is one of the current priorities for the government of England and Wales. More than 5% of British herds currently have their TB free status withdrawn and the infection is spreading geographically, costing ~£90 million/year in testing, compensation, and on diagnosis and vaccine R&D. European badgers (Meles meles) can be chronic carriers and excretors of the bacteria and their role in the transmission of the disease to cattle has been demonstrated (Jenkins and others 2010), although the exact route of transmission is not fully understood. Vaccination of badgers with injectable BadgerBCG (licensed in the UK in 2010) can significantly reduce the development of visible lesions and excretion of M. bovis under experimental conditions (Lesellier and others 2011) and reduce the TB incidence (based on positive serological and culture tests) in cohorts of vaccinated wild badger social groups (Chambers and others 2011, Carter and others 2012). Experimental studies have demonstrated that vaccination of badgers with one dose of oral BCG can be protective, but the challenge is to develop a bait product (in) which: 1/ BCG survives throughout the commercial production process and cold chain, 2/ is attractive to badgers, 3/ is as safe as possible for users and the environment, 4/ is affordable. This work is being undertaken by AHVLA, in collaboration with research groups based in the Republic of Ireland, New Zealand, Spain and France. Progress in this research/product development will be presented.

References

Mycobacterium bovis Infection Induces Bovine Macrophage Apoptosis With Participation Of Apoptosis Inducing Factor (AIF) Nuclear Translocation
Benítez Guzmán, A. 1, Arriaga Pizano, L. 2, Gutiérrez-Pabello, J.A. 3
1Laboratorio de Investigación en Tuberculosis Bovina. Departamento de Microbiología e Inmunología, FMVZ-UNAM
2Unidad Médica de Investigación en Inmuonquímica, Hospital Siglo XXI

Mycobacterium bovis, the causative agent of bovine tuberculosis (BT) brings into play different virulence factors to survive inside of host cells. One of the possible outcomes in this scenario is cell death. Our research group reported for the first time bovine macrophage apoptosis induction associated to Mycobacterium bovis infection. Interestingly, the apoptotic process is different than the one induce by other pathogenic mycobacteria like M. tuberculosis. For instance, apoptosis by M. tuberculosis is caspase-dependent, whereas M. bovis induced a caspase-independent process. We used immunocytochemistry to demonstrate the nuclear translocation of (AIF) in apoptotic M. bovis-infected bovine macrophages. However, the role of mitochondria in this process is not known. In this study, we aimed to identify the mitochondrial participation in M. bovis apoptosis induction. We infected bovine macrophages with M. bovis AN5 (MOI 10:1) during 16 hours and quantified AIF and Endo G translocation to macrophage nuclei by immunoblotting. Our results demonstrated that AIF translocation due to M. bovis infection is 14 fold higher compared with uninfected cells, whereas, the translocation level of Endo G is 2 fold higher after infection. Interestingly, our preliminary results after inhibition of disruption of mitochondrial membrane potential, showed a decrease in the percentage of apoptotic macrophages, suggesting that mitochondria could be a key organelle in apoptosis induced by M. bovis in bovine macrophages.

This work was supported by project PAPIIT IN-217512-2 and CONACYT CB-167488. A. Benítez-Guzmán received a postdoctoral fellowship from DGAPA,UNAM.
Natural Killer Cell Responses Following BCG Vaccination or *Mycobacterium bovis* Infection Of Neonatal Calves

**Hamilton, C.**, **Entrican, G.**, **McNair, J.**, **Hope, J.**

1 *The Roslin Institute, The University of Edinburgh, Easter Bush Campus, Edinburgh, EH25 9RG, Scotland, United Kingdom*
2 *Moredun Research Institute, Pentlands Science Park, Bush Loan, Penicuik, Edinburgh, EH26 0PZ, Scotland, United Kingdom*
3 *Agri-Food and Biosciences Institute, Stoney Road, Stormont, Belfast, BT4 3SD, Northern Ireland, United Kingdom*

**Keywords**

Natural Killer cells, *Mycobacterium bovis*, BCG vaccination

**Introduction**

Vaccination of cattle is a desirable strategy to control bovine TB, however currently there are no licensed vaccines available for use within the UK. Experimental vaccination of neonatal calves with attenuated *M. bovis* BCG provides significant protection against *M. bovis* challenge which has been shown to last for at least 12 months. We hypothesise this enhanced efficacy of BCG in neonates is attributed to the increased number and activity of Natural Killer (NK) cells in young animals. Thus the aim of the present study was to define the response of NK cells using flow cytometry following vaccination of neonatal calves with BCG, or infection with virulent *M. bovis*.

**Materials and Methods**

Neonatal calves were infected with 5 x 10^2 CFU *M. bovis* AF2122/97 delivered by aerosol from a Madison chamber and the frequency, phenotype and function of NK cells were compared to age-matched, uninfected controls. In a separate study, neonatal calves were inoculated subcutaneously with 0.5ml BCG Danish SSI.

**Results**

The *M. bovis* infected, BCG vaccinated and age-matched naive animals were assessed for variations in the response of NK cells *ex vivo*. Subsequent to BCG vaccination or *M. bovis* infection, significant changes in the frequency of NK cells were evident at both early and late time points which coincided with increased activation, migratory potential and effector function of NK cells.

**Discussion/Conclusion**

These observations indicate a role for NK cells in the early phase of anti-mycobacterial immunity.

Assessment Of *Mycobacterium bovis* BCG Vaccination Against Bovine Tuberculosis Of Calves In A Natural Transmission Setting In Ethiopia


1 *Aklilu Lemma Institute of Pathobiology, Addis Ababa University, PO Box 1176, Addis Ababa, Ethiopia*
2 *Armauer Hansen Research Institute, PO Box 1005, Addis Ababa, Ethiopia*
3 *National Animal Health Diagnostic and Investigation Centre, Sebeta, Ethiopia*
4 *Animal Health and Veterinary Laboratories Agency, New Haw, Surrey KT15 3NB, United Kingdom*
Bovine tuberculosis (BTB) is highly prevalent in intensive dairy farms of the urban ‘milk-sheds’ in Ethiopia. Nonetheless, it is not a notifiable disease. As Ethiopia, like other emerging economies, cannot afford to implement a test and slaughter control strategy for both economic and social reasons, vaccination could be an acceptable alternative strategy. In the present study, the effect of BCG on the pathology of BTB was evaluated in 49 (23 vaccinated and 26 control) Holstein-Friesian calves inserted into a herd with high BTB prevalence. The calves were vaccinated with the equivalent of 5 human doses of BCG Danish SSI or with placebo via the subcutaneous route when 2 weeks old. They were then exposed 6 weeks later to the infected herd and kept in contact with infected donor animals for about one year. Gamma interferon, comparative intradermal tuberculin tests, post mortem, histopathological examinations and bacteriological culturing were used to evaluate BCG protective efficacy. By applying a quantitative scoring system, we observed a significant reduction of gross pathology in the vaccinated calves of ~63% (P<0.05). Specifically, gross pathology in the lung lobes, pulmonary, head and alimentary tract lymph nodes was reduced by 59, 46, 87, and 88%, respectively. The percentage of animals presenting without gross pathology increased by 24% in the BCG vaccinated group. In conclusion, BCG vaccination of cattle in Ethiopia could constitute a potent tool to reduce pathology and thereby animal to animal transmission in these high prevalence herds of high economic importance.

Field Efficacy Of single-dose Oral BCG Vaccination In Protecting Cattle From Natural Infection With Bovine Tuberculosis

Aldwell, F.¹, Nugent, G.², Yockney, I.², Whitford, J.², Buddle, B.³,
¹ Immune Solutions, Otago University, PO Box 56, Dunedin 9054, New Zealand
² Landcare Research, P.O. Box 69040, Lincoln 7640, New Zealand
³AgResearch, Hopkirk Research Institute, Private Bag 11008, Palmerston North, New Zealand

Keywords
bovine tuberculosis, cattle, BCG, vaccination, field efficacy

Introduction
Near-final results are presented from a 6-year field trial in New Zealand aimed at determining the efficacy of oral BCG vaccination in protecting free-ranging cattle from natural transmission of bovine tuberculosis (TB) from a multi-host reservoir that includes cattle, possums (*Trichosurus vulpecula*; the primary wildlife host in New Zealand), but also red deer (*Cervus elaphus*), feral pigs (*Sus scrofa*) and ferrets (*Mustela furo*).

Methods
Between early 2009 and mid-2011 five annual cohorts of cattle were tuberculin tested (caudal fold; CFT) tested for TB. CFT-negative cattle were included in the trial, and ~half of them were orally vaccinated with a single dose of live BCG vaccine. The cattle were slaughtered 1-5 years later, and their TB status determined through slaughterhouse inspection and subsequent mycobacterial culture of retropharyngeal, mediastinal, and bronchial lymph nodes.

Results
Blood-testing of the 2006 cohort soon after inclusion, and of the 2010 cohort at the time of inclusion, indicated that 1.2-2.2% of the CFT-negative cattle were likely to have been infected when included in the trial. The first four cohorts were vaccinated with 108 cfu of BCG. By late 2013, 4.4% of 544 vaccinates had been provisionally diagnosed (culture confirmation pending for some) as TB positive, significantly lower than in 434 non vaccinates (9.5%, p = 0.002).

Discussion
Taking into account the likelihood of prior infection, the results suggest that single dose oral BCG vaccination is likely to have an efficacy of between 60-80% in protecting cattle from natural infection from wildlife and cattle. The potential role(s) of vaccination in TB management in New Zealand are explored.
Bovine Tuberculosis Policy and Legislation: A European Commission Perspective
Reviriego-Gordejo, F.J., *European Commission, Health and Consumers Directorate-General, G2 - Animal Health, Head of Sector Disease Control and Identification*

Knowledge of the background of the EU policy on bovine tuberculosis (bTB) helps to understand the current situation and to envisage the future policies. Four milestones in the history of EU bTB deserve attention: a) the EU Trade Directive (Directive 64/432/EEC), b) the setting of the EU goal of bTB eradication (Directive 77/391/EEC), c) the EU financial support for bTB eradication (Decision 90/424/EEC) and d) the EU strategy for the single market in the field of animal health (1992).

Understanding bTB in the EU requires special attention to the wider EU epidemiological situation. Currently 19 out of 28 EU Member States are entirely or partially officially bTB free and 1263 out of 1582 of EU regions (80%) are officially bTB free. In 2012, 0.67% of EU cattle herds were found infected with bTB and only 125 human cases of tuberculosis were caused by *M. bovis*. The situation in the officially free EU Member States is closely monitored and it remains stable with well-defined pockets of residual infection where local risks are identified though the affective surveillance that is in place using the different suitable tools available under the different surveillance strategies applied in each area.

Future bTB policies will be integrated within the EU Animal health Strategy and therefore the basic concepts of that strategy such as a) the definition of priorities, b) a modern EU legal framework, c) strengthened prevention and control and d) science, innovation and research will be the pillars for any future development.

Bovine Tuberculosis Eradication Programmes In The EU - Experiences From Balancing Science and Policy
Sternberg Lewerin, S.1, Good, M.2, Saéz Llorente, J.3, Zanardi, G.4, Evans, L.5, Preto, I.6, Bezos Garrido, J.7, Pacciarini, M.5, Piazza, V.8,
1SLU, Almas Allé 10, 750 07 Uppsala, Sweden
2Bovine TB Eradication Programme, Department Agriculture, Food and the Marine, Ireland
3MAGRAMA, Paseo de la Infanta Isabel, 1, 28014 Madrid, Spain
4ISZLER, Italy
5AHVLA, UK
6DGAV, Largo da Academia Nacional das Belas Artes , n.º2, 1249-105 Lisboa, Portugal
7VISAVET, Universidad Complutense, Spain
8Veterinary, European Commission, DG Health and Consumers, Directorate G – Veterinary and International Affairs

Keywords
EU co-financed TB eradication programmes, monitoring, European Union

Introduction
The EU Commission’s Task Force for monitoring animal disease eradication was set up in 2000, the subgroup for bovine tuberculosis was among the first created. The subgroup revised the Working Document on the eradication of bovine tuberculosis in the EU in 2012 (published 2013).

Materials and methods
Experiences, as documented in the reports from visits to member states and in the Working document, were compiled by the subgroup.
Results and discussion

Some general issues that are important to all eradication programmes include disease definition, programme organisation, training and education, quality control, data analyses, enforcement and stakeholder involvement. Specific issues that must be adapted to the regional situation include definition and application of the epidemiological unit, use and interpretation of different diagnostic tests, management of infected herds and surveillance.

The subgroup suggests that bovine tuberculosis be defined as “infection in all Bos species by any disease-causing species in the *M. tuberculosis*-complex”.

Education, training and quality assurance is important on all levels of the control programme but the specific needs vary depending on the structure of the organisation in different member states.

We have seen a need for many local and regional science informed adaptations of control and eradication tools such as the use of different test combinations, testing frequency, test interpretation, targeted surveillance and eradication strategy in individual herds. A key to success is the access to, and continuous epidemiological analyses of, relevant data to monitor, assess and strengthen the programmes.

Evolution Of French Policy Measures To Control Bovine Tuberculosis In Regards To Epidemiological Situation

**Fedieavsky, A.**, Desvaux, D., Chevalier, F., Gueriaux, D., Angot, J.L.,

1*Direction générale de l’Alimentation (DGAl), Ministère de l’Agriculture, de l’Agroalimentaire et de la Forêt, Paris, France*

2*Direction régionale de l’Agriculture, de l’Alimentation de Languedoc Roussillon*

3*Direction régionale de l’Agriculture, de l’Alimentation et de la Forêt de Bourgogne*

**Key Words**


The French eradication policy against bovine tuberculosis started in the mid 1950’s to achieve officially free status fifty years later. During the last decade several epidemiological events challenged the situation.

The main changes in the policy and tools against bovine tuberculosis are briefly criticised acknowledging changes in disease epidemiology. The main characteristics of the current situation are described to identify issues and seek for the response in terms of policy making.

Initially, the public authority was concerned by public health issue and economical loss. Weak involvement of farmers was a major issue. Awareness campaigns, promoting farmer organisations for animal health and vaccination preceded enforcement of a compulsory eradication program. With the reduction of the prevalence rate, new issues arose such as lack of specificity of diagnostic and lack of efficiency of eradication protocols. In response, increased standardisation of diagnostic protocols and stamping out were adopted. As the prevalence rate went down below 1%, in-farm surveillance was progressively lifted.

The current situation is characterised by a prevalence rate lower than 0.1% but cases are detected in some areas. The threat of an extension of the infection led to a national action plan. It addresses issues such as reinvoking involvement about a “past” disease, low positive predictive values of diagnostic tests, scarcity of gross lesions, surveillance and control of wildlife, strategy of eradication in infected herds.

Control policy evolves with changes in the perception of the epidemiology, however the international framework, which is necessary, may sometimes be a constraint to adress specific situations.
Introduction Of Annual Testing As A Cornerstone For TB Eradication In Wales

Glossop, C., Griffiths, R., Office of the Chief Veterinary Officer, Department for Natural Resources and Food, Welsh Government, Cathays Park, Cardiff, CF10 3NQ, UK

Keywords
eradication, surveillance, early identification of infection, veterinary capacity

The Welsh TB Eradication Programme aims to tackle all sources of infection through a comprehensive package of measures. A key component of the programme is rapid early identification of infection. At the outset, testing frequency varied across Wales and was calculated in accordance with Council Directive 64/432/EEC on a parish basis. To establish a more accurate picture of the disease situation, a one-off test of all cattle herds in Wales (“TB Health Check Wales”) was conducted over a concentrated timeframe of a 15 month period (ending December 2009), which required an additional 3,500 herd tests to be carried out. Results supported a move to an annual testing regime across the whole country, and this policy has been in place since 2010.

This paper will discuss the logistics of increasing testing frequency in terms of consideration of veterinary capacity and farmer attitude. It will also present TB incidence figures in Wales since 2009, the number of cattle slaughtered, and the resources required to deliver the policy. It will also highlight the opportunity to impart biosecurity and other disease prevention advice to cattle keepers made possible by this annual veterinary visit, funded by Government.

Evidence Informed Policy: What’s In A Number?


1Department of Veterinary Tropical Diseases, University of Pretoria, South Africa.
3Centre for Veterinary Epidemiology and Risk Analysis, University College Dublin, Ireland.
4Office of the Chief Veterinary Officer, Welsh Government, Cardiff, Wales.
5Veterinary Epidemiology Unit, Department of Agriculture and Rural Development, Belfast, Northern Ireland.
7Veterinary and Science Team, Rural and Environmental Directorate, Scottish Government, Edinburgh, Scotland.
8Department of Agriculture, Food and the Marine, Celbridge, Ireland.

Keywords
Bovine Tuberculosis, Eradication Programme, data, policy.

Analysis of data collected routinely within national animal health programmes provides valuable information for monitoring disease trends and progress towards eradication. The data also facilitate comparisons between regions and support epidemiological or modelling studies. European Union (EU) member states with financial assistance for their bovine tuberculosis (BTB) eradication programmes are obliged to submit regular summary reports using prescribed templates. The data from these are used by EU officials to monitor and report progress. It is essential that the results of these analyses are both
Infection Dynamics and Effective Control Options Of Tuberculosis In Cattle and Badgers

Aznar, I. 1, Frankena, K. 2, Byrne, A.W. 1, More, S.J. 1, De Jong, M.C.M 2

1Centre for Veterinary Epidemiology and Risk Analysis, UCD School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland
2Quantitative Veterinary Epidemiology group, Wageningen Institute of Animal Sciences, Wageningen University, P.O. Box 338, 6700 AH Wageningen, The Netherlands

In the Republic of Ireland (ROI), bovine tuberculosis (bTB) transmission between badgers and cattle has hindered national eradication efforts in cattle (Good 2006). Additional control measures are needed, either directed against the transmission of infection among badgers, among cows or a combination of both. Mathematical modelling is an essential tool to understand the maintenance and transmission of multiple host diseases as well as to assess the impact of control measures. The objectives of this paper are twofold. Firstly, two simple mathematical models were built to separately estimate the reproduction ratio $R$ for bTB transmission between cattle and between badgers in Ireland with the current control strategies ($R_{cc}$ and $R_{bb}$). Secondly, for each species, $R$ under additional control strategies ($R^{1}_{cc}$ and $R^{1}_{bb}$) will be obtained and the potential effects of new control options will be evaluated. To assess additional control options we postulate that: a) if we apply new control options in badgers (the same can be postulated when control measures are applied in cattle), and $R^{1}_{bb}$ is $< R_{bb}$, then the applied measures will have a positive effect in reducing the $R$ for the system b) if is $R^{1}_{bb} <1$, then eradication in cattle will be possible if the transmission matrix is “disjunct”, c) otherwise, if the transmission matrix for the system is “separable”, bTB eradication in cattle will only be possible if $R^{1}_{bb} < (1-R_{cc})$. The outcomes from these models are discussed; these outcomes will help decision makers to optimize future control options for bTB in Ireland.

Bovine Tuberculosis In Mexico, Its Control and Eradication, Achievements and Challenges


Keywords

bovine tuberculosis, surveillance, strategic plan

This presentation describes the Eradication Program of the National Campaign against Bovine Tuberculosis in Mexico, from its origins, how was influenced by specific internal and international trade, also mentions how it’s evolved.

Currently Mexico has a Strategic Plan of the Campaign, and relevant indicators to assess the operation, in 2011 through analysis of surveillance, there is a nationwide 90% inspection of all cattle slaughtered, with a rate of collecting and shipping samples of 1.75 (ratio: at least 1 per 2000 head slaughtered), the epidemiology of the disease with a success to locate the most likely herd of origin 86% and to confirm the infection of 33.1%. 380 infected herds were depopulated in 6 years. The national average time to get a sample from slaughter house to the laboratory is 4 days (the indicator is 10 as maximum), in addition has a system of movement control and training enhanced. As well, to control the movement of animals, Mexico has 45 federal inspection points, and also the States administer other 318 points.

The Government agency in charge of the Eradication Campaign is: The National Service of Health, Food Safety, and Food Quality (SENASICA), which has set up new goals to comply with during the 2013 – 2018 period. All this under the strict supervision of the use of public resources which have invested approximately 51.7 million USD in the last 6 years and the application of a strong legal framework and adapted to technical and legal requirements. But the challenge is also according to the characteristics of the breeding and marketing of livestock in Mexico.

Describes achieves despite the economic and technical limitations, achieving the 2011 objective obtaining 83% of the national territory with prevalence less than 0.5%. So it is important to mention because it is working for an expectation of 95.5% of the national territory with less of 0.5% and below 5% in areas of dairy in 2020.

Test and Vaccinate Or Remove (TVR) Badger Intervention Research – An Effective Middle Way?

McKee, I., Head of TB Policy, Dept of Agriculture and Rural Development, Northern Ireland

Following discussion with industry stakeholders, and informed by the views of experts who attended the International TB Vaccination Symposium in Belfast in May 2012, officials in Northern Ireland (NI) were tasked to design specific wildlife intervention research to add to the knowledge base and not simply duplicate work being done elsewhere. Following detailed consideration, a TVR badger intervention research project based, where possible, on scientific principles was approved on 1 May 2014.

TVR will involve the testing of live badgers for bTB; vaccinating and releasing the test negative badgers; and removing the test positive ones. The first year of the project involves vaccination and blood sampling to establish a baseline of disease prevalence in badgers; and to help mitigate any potential adverse effect from possible perturbation following removal of TB infected badgers from year 2 onwards. Ongoing ecology monitoring will take place throughout the 5 year research period until 2018.

TVR has secured broad spectrum support from farming, environmental and veterinary representative organisations.

Amongst other benefits, this project will provide data to help improve the accuracy of TB modelling applied to NI disease situation in cattle and wildlife by collecting specific data on parameters such as badger TB prevalence and demographics. It will also provide data to enable examination of the molecular types of any M.bovis isolates from badgers and cattle in the TVR area to assist in quantifying the contribution badgers make to bovine TB levels in cattle. It will provide temporal and spatial information on the heterogeneity of M.bovis infection in badgers in NI; including the degree of clustering of infection; and how this changes (if at all) over time. Changes to bTB incidence in cattle herds will be assessed with reference to non intervention matched areas.

Will TVR be a part of the answer? Will it establish that there is an effective, affordable and more socially acceptable middle way between less discriminate culling regimes and vaccination, at least in certain situations? Time will tell.
An Epidemiological Study of Risk Factors that Affect the Rate of Expansion of the Area Affected by Endemic Bovine Tuberculosis.

Brunton, L.A.¹, Alexander, N.², Wint, W.², Ashton, A.¹, Goodchild, A.¹ & Broughan, J.¹

¹Animal Health and Veterinary Laboratories Agency, United Kingdom.
²Environment Research Group Oxford, United Kingdom.

Keywords: bovine tuberculosis, endemic, spread, risk factors

Introduction
An understanding of the factors that affect the spread of endemic bovine tuberculosis (bTB) is critical for the development of measures to stop and reverse this spread. The rate of expansion of the endemic area varies geographically in England and Wales, so understanding what factors are important at a local level could guide the implementation of tailored local controls.

Materials and methods
A novel approach was developed to map the expansion of the endemic area between 2001 and 2012 and calculate the rate of expansion. The influences of a range of environmental, farm management and landscape risk factors on the speed of the spread of the endemic front were examined using classical linear regression models and geographically weighted regression to account for the fact that the variables of interest are not fixed over space.

Results
A great deal of spatial variation was observed in the most influential risk factors associated with the spread of endemic bTB. The direction of the associations varied geographically for all of the variables, indicating that in some areas a variable might be associated with a reduction in the rate of spread whilst in others it might be associated with an increase in the rate of spread.

Discussion/Conclusion
A complex pattern emerges when the spread of bTB is modelled at a regional level. This complex picture should be investigated further to help understand how policies could be tailored to tackle bTB at a regional level.

Understanding and Managing bTB Risk: perspectives from Ireland
Simon More, University College Dublin

The presentation of bovine tuberculosis (bTB) in Ireland has a number of consistent features, including spatial clustering and local persistence. There has been an intensive programme of scientific work for some years to better understand the what (the key factors influencing bTB risk) and the why (the biological basis for the observed risk). This work is undertaken in collaboration with national policy, thereby enabling policy makers to best manage these risks (the how). This presentation will present an overview of current understanding of herd-level risk factors in Ireland, and of reasons for local persistence, including their relative importance. With improved scientific knowledge, there have been ongoing policy changes, and ongoing national progress towards improved control. Consideration will be given to lessons learned and ongoing challenges.