Genomic Insights Into The Biology Of *Mycobacterium bovis*
Gordon, S.V., School of Veterinary Medicine, University College Dublin, Ireland

The sequencing of the *Mycobacterium bovis* AF2122/97 genome in 2003 heralded the start of the genomic age for the bovine tubercle bacillus. This first genome took ~3 years to sequence and annotate; in the intervening decade sequencing costs have plummeted and speed has dramatically increased, making the production of a bacterial genome sequence no more than a few weeks work. The challenge now is to add biological interpretation to genome sequences; how can the burgeoning stocks of pathogen genome data be best exploited for the development of disease control tools? This presentation will highlight how genome-level data from *M. bovis*, and in particular comparative analyses with the human pathogen *Mycobacterium tuberculosis*, is being used to provide biological insight into the molecular workings of *M. bovis*.

Host Responses To Mycobacterial Infections: Spotlight On Biomarker Discovery To Predict Vaccine Efficacy
Vordermeier, H.M.1, Buddle, B.M.2, Waters, R.3, Villarreal-Ramos, B.1, Golby, P.1, Aranday-Cortes, E.1, Hogarth P.J.1, Hewinson, R.G.1,
1Animal Health and Veterinary Laboratories Agency, Weybridge, Surrey, UK
2AgResearch, Hopkirk Research Institute, Palmerston North, New Zealand
3USDA-ARS-NADC, Ames, Iowa, USA

Keywords
*Mycobacterium bovis*, vaccination, cattle, biomarkers, protective correlates

The global spread of tuberculosis (TB) in animals and humans result in enormous economic, social and public health burdens. TB vaccine development in both humans and animals has produced a growing portfolio of candidates with potential applicability across species. However, the lack of understanding of the underlying biological mechanisms and the lack of correlates of protection that can guide vaccine design or animal experiments, or that can be used as a credible endpoint in field trials are hampering progress. The bottleneck for cattle vaccine development is the expense and paucity of BL3 facilities. Reliable gating criteria to select only the most promising vaccine candidates for testing in BL3 experimentation or field trials would greatly accelerate the pace of vaccine development. Hence, significant research efforts have been directed towards develop and validate such biomarkers using hypothesis - as well as data-driven approaches including host transcriptome and proteome analysis combined with a systems biology philosophy.

Vaccination outcome based on relevant clinical endpoints allows the classification of vaccinated cattle in those that were successfully vaccinated, and those in that vaccination was unsuccessful. This is a powerful way of stratifying data to identify biomarkers that predict vaccine efficacy (*i.e.* those that be measured post-vaccination but without the need for *M. bovis* challenge), markers that correlate with protective immunity (*i.e.* those that can be measured after *M. bovis* infection that will give insights into the nature of protective immunity), or markers that correlate with disease progression (measured after challenge that can serve also as inverse correlate of protection as these markers are generally of lower magnitude in successfully vaccinated animals post-challenge).

I will present an update on the significant progress that has been made in the discovery of such biomarkers (see table below for overview) as well as discuss how these markers can be used to extend our understanding of the fundamental processes underlying the host responses against bovine tuberculosis, both protective and immune pathogenic.
Practicalities Of The Immune-based Diagnostic Assays For The Control Of Bovine Tuberculosis

Bakker, D., Department of Bacteriology and TSE’s, Central Veterinary Institute of Wageningen University, P.O. Box 2004, 8203AA Lelystad, The Netherlands

Isolation by culture of *M. bovis* and subsequent speciation by molecular methods is usually considered to be the gold standard for the diagnostic confirmation of tuberculosis in an animal or herd. However, culture and more recently the detection of *M. bovis* by PCR, are in the veterinary field almost exclusively used post mortem.

For the ante mortem diagnosis of bovine tuberculosis, the use of immune-based diagnostic assays allowing the detection of the predominant, pre-clinical cell mediated immune response are more appropriate.

In the early 1890’s, Bernhard Bang introduced the intradermal test as the diagnostic tool in the control of bovine tuberculosis in Denmark. The “Bang method” as it was called, consisted of a repetitive, six-monthly, use of the intradermal assay and separating test-positive and test-negative cows, and only culling cattle with “tuberculosis of the udder”. Following reports on the achievements using his approach this “Bang method” was accepted worldwide as the major tool in the control of bovine tuberculosis. This repetitive use of the intradermal assay is still the basis of all control programs for bovine tuberculosis.

Koch’s Old Tuberculin (KOT), used as the stimulating antigen in the intradermal test in the early intradermal assays, was developed in Koch’s search for “the active principle of tuberculin” to be used for the treatment of human tuberculosis. At first, the importance of the skin reaction as a diagnostic tool was not recognised and even regarded “not to be noteworthy and to be insignificant”. However, as part of his search for the active components present in the KOT, Koch introduced the guinea pig assay to test the “potency” of the sub-fractions obtained in the different purification steps. Currently, this assay, using *M. bovis* infected guinea pigs, is still being used to assess the potency of the tuberculins.

In the 1930’s a major improvement in the quality of the tuberculins, replacing Koch’s Old Tuberculin, was achieved by the work of Florence Seibert. The use of a synthetic medium and precipitation methods, facilitated a more reproducible and a large scale production of these so-called PPD (purified protein derivative) tuberculins or PPD’s.

Despite these improvements, and as reported at international meetings before, a comparison of the commercially available PPD’s in bioassays, using both guinea pigs and cattle, shows disparity in uniformity of the quality of the avian and bovine PPD’s, respectively: whereas the specificity and the potency by weight of the avian PPD’s was shown to be remarkably constant, the specificity and, in particular, the potency per weight of the bovine PPD’s were more variable. If applied in a dose of 1mg/ml the majority of these tuberculins would not meet the required minimal dose of 2,000 I.U..

However, these disparities between PPD’s on the market can not only be attributed to the known differences in production methods or production strains used by the respective producers: analyses of the results of multiple guinea pig assays performed on (the same) batches of avian and bovine PPD in the same lab indicate that results can vary between tests and that a (more) careful interpretation of the potency test results is needed.

Moreover, different producers as well as reference laboratories use testing protocols: *e.g.* for the sensitisation of the guinea pigs, live *M. bovis* AN5, heat-killed *M. bovis* AN5 as well as *M. bovis* BCG are being used, most likely resulting in a difference in potencies as well. This makes it rather difficult for the end users, most of them not having the facilities needed to test for the potencies of the PPD’s to assess the actual potencies of the PPD’s on the market.

Furthermore, the International Standard for bovine PPD, produced by CVI-Lelystad and adapted by the WHO as such in 1987 after a collaborative study, seems to be close to the end of its lifetime.

The PPD’s are not only used in the intradermal assay, but as well as antigen in the gamma-interferon release assay and in the ELISA assays, both currently used as ancillary tests. The use of different sources of PPD’s have been shown to result in different levels of responses in both assays, further illustrate the need for a better standardisation of the potency of PPD’s.
The above findings have a great potential impact on the continuity and standardisation of tuberculosis control programmes in and between countries, e.g. on the free trade of animals between EU member states.

Resolving the observed issues would therefore be of benefit to a wide range of aspects involved in the control of bovine tuberculosis.

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**Bovine Tuberculosis and Social Science: What Is It and How Can It Help?**

**Enticott, G., School of Planning and Geography, Cardiff University, Glamorgan Building, King Edward VII Avenue, Cardiff, Wales, CF10 3WA, UK**

This plenary paper focuses on the role of social science in the management, regulation and governance of bovine tuberculosis. The paper will consider the nature and purpose of social science; the reasons behind the growth in bTB focused social science research; and how its use and application varies internationally. Using examples, the paper will show how social science can contribute to an understanding of a range of different social and behavioural conundrums facing bTB policy makers such as: how can we convince people to accept wildlife controls? Why won’t some farmers adopt biosecurity measures? Why is disease surveillance poorly implemented and what can be done to change these behaviours? The paper will suggest that whilst social science can help answer some of these questions, the purpose of social science is to raise questions as well as answer them. In this respect, the paper will consider the limits to social science itself – to what extent and in which socio-political contexts can it provide answers to the challenges of bTB management? Or is the purpose of social science to stimulate debate about the unspoken awkward questions, different perspectives and framings of bTB which attempts at managing bTB need to address?
Development and Evaluation Of A DIVA Skin Test For Bovine Tuberculosis.

Jones, G.J.\textsuperscript{1}, Coad, M.\textsuperscript{1}, Whelan, A.\textsuperscript{1}, Clifford, D.\textsuperscript{2}, Buddle, B.M.\textsuperscript{3}, McNair, J.\textsuperscript{4}, Thakur, A.\textsuperscript{5}, Jungersen, G.\textsuperscript{5}, Vordermeier, H.M.\textsuperscript{1},

\textsuperscript{1}Department of Bacteriology, Animal Health and Veterinary Laboratories Agency, Weybridge, UK
\textsuperscript{2}Animal Services Unit, Animal Health and Veterinary Laboratories Agency, Weybridge, UK
\textsuperscript{3}AgResearch, Hopkirk Research Institute, New Zealand
\textsuperscript{4}Agri-Food and Biosciences Institute, Bacteriology Department, Veterinary Sciences Division, Northern Ireland
\textsuperscript{5}Section for Immunology and Vaccinology, National Veterinary Institute, Technical University of Denmark, Denmark.

Keywords
DIVA, skin test, BCG-vaccination, \textit{M. bovis}

Introduction
Current vaccine strategies for bovine TB include the use of BCG. However, BCG-vaccination sensitises the animal to bovine tuberculin and compromises the specificity of the tuberculin tests currently used to diagnose bovine TB. Thus, it is essential that diagnostic tests capable of differentiating infected from uninfected vaccinated animals (‘DIVA’ tests) are developed.

Material and Methods
Protein and peptide cocktails representing the antigens ESAT-6, CFP-10, Rv3615c and Rv3020c were formulated and injected intradermal into the neck of cattle. Avian and bovine tuberculin were used as controls. Skin induration at the injection sites was measured prior to and 72 hours after the skin test, and the results expressed as the difference in skin thickness between the two readings.

Results
In \textit{M. bovis}-infected animals tested simultaneously with protein and peptide formulations, the protein DIVA reagent of ESAT-6/CFP-10/Rv3615c induced significantly greater increases in skin thickness compared to the peptide DIVA reagent. For a cut-off value of ≥ 2mm increase in skin thickness, the protein DIVA reagent identified additional \textit{M. bovis}-infected animals when compared to the peptide reagent. Furthermore, addition of Rv3020c to the protein DIVA reagent resulted in a greater number of test positive responders when compared to the ESAT-6/CFP-10/Rv3615c protein cocktail. Use of these DIVA skin test reagents in (i) non-infected; (ii) BCG-vaccinated, or (iii) MAP-infected animals demonstrated a high degree of specificity for the reagents.

Conclusions
The protein DIVA skin test reagent (ESAT-6/CFP-10/Rv3615c) demonstrated an advantage over peptides, and test sensitivity could be enhanced by the inclusion of Rv3020c without impacting specificity.
Adjustments and Controls In The Use Of Bovigam B1G To Improve The Reproducibility

Moyen, J.1, Gares, H.1, Holbert, S.3, Boschiroli, M.2,

1Laboratoire Départemental d’Analyses et de Recherche de Dordogne, 161 Av. Churchill, 24660 Coulounieix-Chamiers
2Laboratoire National de Référence Tuberculose bovine, Unité Zoonoses Bactériennes, Laboratoire de Santé Animale, Anses, 23, avenue du Général de Gaulle, 94706 Maisons-Alfort cedex
3UMR1282, Infectiologie et Santé Publique (ISP-311), INRA Centre Val de Loire, F-37380 Nouzilly France

Interferon gamma releasing assay (IGRA) allows sensitive and early detection of bovine tuberculosis (bTB). Several technical aspects of the test may introduce a lack of reproducibility reducing its accuracy. For instance, Elisa OD values depend on sensitivity of the employed batch but also on environmental factors. Moreover, Th1 stimulation depends on the purity and on the activity of the employed antigens.

In order to control these points various improvements were introduced in the French laboratory network. Each employed batch is validated before delivery and a positive control dilution is determined to adjust a constant detectability from batch to batch. A reference material with an invariable expected value is used on each plate. Results are expressed as a ratio with the normalised positive control to warrant reproducibility.

The intralaboratory variation depends on the laboratory and on the batch (5-12%). This variation is about half of that observed when using the current interpretation-formula recommended by Bovigam kit. The interlaboratory variation of the reference material with our overall system, which is about 12%, allows a decrease of the uncertainty.

Validation of antigen batches using peripheral blood mononuclear cells (PBMC) from bTB infected and uninfected animals is currently being assessed.

Normalisation and standardisation between laboratories, reduces the method’s incertitude, allows a better comparison of result in order to validate new antigens and to determine regulatory cut-off values. This standardisation is necessary to employ IGRA at a large national wide-scale in the framework of decisional schemes.

Immune Response To Experimental M. bovis Infection In Cattle Naturally Infected With M. paratuberculosis

Roupie, V.1, Alonso-Velasco, E.1, Van der Heyden, S.2, Duytschaever, L.1, Van Campe, W.3, Mostin, L.3, Roels, S.2, Huygen, K.4, Fretin, D.1,

1Unit “Bacterial Zoonoses of livestock”, Operational Direction Bacterial Diseases, Veterinary and Agrochemical Research Centre (CODA-CERVA), Groeselenberg, Brussels, Belgium
2Service Orientation and Veterinary Support, Veterinary and Agrochemical Research Centre (CODA-CERVA), Groeselenberg, Brussels, Belgium
3Experimental Center, Veterinary and Agrochemical Research Centre (CODA-CERVA), Kerklaan 68, Brussels, Belgium
4Service Immunology, WIV-ISP-Site Ukkel, Brussels, Belgium

Keywords
experimental infection, M. bovis, M. paratuberculosis, Quantiferon TB Gold In-Tube, histopathology
The aims of this study were to evaluate in the context of bovine tuberculosis diagnosis 1) the influence of MAP infection on whole-blood IFN-γ assay 2) the potential of Quantiferon TB® peptide cocktail and 3) the influence of single cervical skin test (CIT).

Four male Holstein bulls aged approximately 19 months at time of infection and naturally infected with MAP were infected intratracheally with 1,5 X 10^5 CFU of a Belgian field strain of \textit{M. bovis} grown as a biofilm culture. Two control animals were not infected with \textit{M. bovis}. Blood was sampled every two weeks for the six animals by jugular venipuncture in heparinised Vacutainer tubes. Nasal swabs and faeces were collected at the same time. The blood was stimulated with PBS (Nil control), PPDA and PPDB (Prionics), recombinant ESAT-6 protein, peptide pools of ESAT6-CFP10 or pokeweed mitogen and tested for IFN-γ release after 20hr (Bovigam 2G). After 16 weeks of infection CIT test was performed and blood was sampled every 2-3 days until sacrifice 17 days later. Thirty organs were collected and stored for histopathological examination, MAP and \textit{M. bovis} culture and Ziehl Nielsen analysis.

Based on PPDA/PPDB stimulation, diagnosis of bovine tuberculosis was not be influenced by concomitant paratuberculosis infection. After the CIT, all four \textit{M. bovis} infected cattle showed an increase of specific IFN-γ production in response to PPDA/B. One control animal also reacted, but this boost effect had disappeared 14 days post-CIT.

**Critical Points In Laboratory Protocols For Bovine Tuberculosis Diagnosis**

\textbf{de Juan, L.}^{1,2,3} \textbf{Romero, B.}^{1} \textbf{Bezos, J.}^{1,4} \textbf{Álvarez, J.}^{5} \textbf{Casal, C.}^{1} \textbf{Liandris, E.}^{1,3} \textbf{Lozano, F.}^{1} \textbf{Alende, T.}^{1} \textbf{Gimeno, J.}^{1} \textbf{Domínguez L.}^{1,2,3} \\
\textsuperscript{1}VISAVET Health Surveillance Centre. Universidad Complutense de Madrid. 28040 Madrid. Spain \\
\textsuperscript{2}Departamento de Sanidad Animal. Facultad de Veterinaria. Universidad Complutense de Madrid. 28040 Madrid. Spain \\
\textsuperscript{3}CEI Campus Moncloa, UCM-UPM, Madrid, Spain \\
\textsuperscript{4}MAEVA SERVET SL. C/ de la Fragua 3, 28749, Alameda del Valle, Madrid, Spain \\
\textsuperscript{5}Department of Veterinary Population Medicine, University of Minnesota, St. Paul, MN, USA

**Keywords**

EU-RL for Bovine Tuberculosis, ring trials, NRL, standardisation.

The Commission Regulation 415/2013 specifies the responsibilities of the European Union Reference Laboratory (EU-RL) for bovine tuberculosis. Among them, the EU-RL shall organise laboratory comparative tests of diagnostic procedures for the National Reference Laboratories (NRL) to facilitate the harmonisation of techniques throught the Union.

The EU-RL has organised five comparative tests in the last two years devoted to IFN-g detection, culture and direct PCR, evaluation of culture media, sensitivity of PCR, and MIRU-VNTR analysis. Samples (plasma, lymph nodes, bacteria suspension or DNAs) were distributed to the participant NRLs.

An overview of the critical points for each technique will be discussed focusing mainly in the main aspects that differ from each laboratory (different cut-off point in the IFN-g test, commercial kits, sample decontamination, culture media, PCR target, assignment of repetitions, etc.).

Harmonisation of protocols is crucial and the EU-RL has to ensure high quality and standarisation of laboratory testing of bovine tuberculosis across the European Union.

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Sensitive and Specific Diagnostic Assay For Detection Of Tuberculosis In Cattle
1Department of Bacteriology, Immunology and Mycology, Faculty of Veterinary Medicine, Sadat city University, Egypt
2Rapid diagnostic unit (Company of Bio-products and Vaccines; Vacsera, Egypt)
3Department of Physiology, Faculty of Veterinary Medicine, Sadat city University, Egypt
4Department of Parasitology and Animal Diseases, National Research Center, Giza, Egypt
5Department of Pathology, Faculty of Veterinary Medicine, Sadat city University, Egypt
Department of Milk & Meat Hygiene, Faculty of Veterinary Medicine, Sadat city University, Egypt
6Department of Animal Welfare, Faculty of Veterinary Medicine, Sadat city University, Egypt
8Department of Nutrition, Faculty of Veterinary Medicine, Sadat city University, Egypt
9Department of Chemistry, Division of Biochemistry. Faculty of Science, Cairo University, Giza, Egypt
10Department of Bacteriology, Immunology and Mycology, Faculty of Veterinary Medicine, Alexandria University, Egypt

Key Words
Bovine Tuberculosis, Tuberculin Test, ELISA, Dipstick Assay

The present study was planned to estimate the sensitivity of the single intra dermal tuberculin test, dipstick assay, ELISA (using Bovine PPD, Cured culture filtrate, ESAT-6, MBP70 and CFP10) and histopathological examination of the positive slaughtered animals for the detection of bovine tuberculosis (BTB). A total number of 1850 of cattle from different farms in Egypt were examined for BTB by tuberculin intradermal test using mammalian purified protein derivative (MPPD). A total of 36/1850 (1.90%) were positive reactors by single cervical test. Histopathological examination of 288 lymph nodes and 72 organ tissues (Liver and Lung) revealed that 75 lymph nodes and 25 organ tissue samples showed typical granuloma for tuberculosis. The percentage of the collected samples from those showing positivity by Ziehl Neelsen stain was 52.43% (151/288) for the lymph nodes and 56.94% (41/72) for liver and lung tissues. Positive reactors of ELISA assay using different antigens for skin tuberculin tested cattle were increased to 61.67 and 63.33% by using ESAT-6 and MPB70, respectively. Generally, the sensitivity and specificity of ELISA and dipstick assays were recorded 100% by using crude culture filtrate and CFP10 as capture antigens. The range of sensitivity (89-97%) and specificity (88-96) was slightly decreased by using Bovine PPD, ESAT-6 and MPB70 for serodiagnosis of BTB. The study has provided a clearer understanding of the kinetics of antibody responses to defined mycobacterial antigens at the subclass level in bovine tuberculosis and has made it possible to develop a novel dipstick system which may be useful in disease diagnosis. In conclusion, the dipstick of the present study is inexpensive (relative to ELISA), sensitive and specific diagnostic assay for detection of tuberculosis in cattle and could be particularly useful in developing countries or remote areas that may lack access to expensive testing equipment for diagnosis of tuberculosis.
Diagnosis Of Bovine Tuberculosis In Mozambique - Comparison Of Diagnostic Methods
Maxhuza, G.¹, Machado, A.², Tanner, M.³, Moser, I.⁴,
¹National Department of Veterinary Services, Ministry of Agriculture, Maputo, Mozambique
²Veterinary Faculty, Eduardo Mondlane University, Maputo, Mozambique
³Institute of Infectious diseases and Zoonoses, Ludwig-Maximilian-University, Munich, Germany
⁴Friedrich-Loeffler-Institut, Institute of Molecular Pathogenesis, Jena, Germany

Keywords
Bovine tuberculosis, prevalence, diagnosis, efficiency

The prevalence of bovine tuberculosis (bTB) in cattle in Mozambique varies considerably between different areas. While in Govuro district bTB prevalence is around 60%, in Massingir district it is less than 1%. Control strategies are difficult to implement due to long distances, lack of laboratory facilities in the country as well as complexity of diagnostic methods. Therefore, the efficiency of different available ante mortem and post mortem diagnostic methods was compared by investigating a bTB positive cattle herd. Single intradermal cervical comparative tuberculin (SICCT) test, IDEXX antibody test, meat inspection of slaughtered animals and bacteriological culture of suspect tissue were compared. Culture isolates have still to be confirmed as M. bovis. Altogether 94 cattle were examined but not all of them with every method by now. In general, while SICCT detected 77% of 90 tested animals, IDEXX ELISA detected 67% of 33 animals. Post mortem inspection revealed suspect lesions in 94% of 94 animals, bacterial growth was observed in 73% out of 41 samples. This means that meat inspection had the highest sensitivity to detect suspect animals. Analysing the accordance between different methods, SICCT detected 75.3% and IDEXX ELISA 67.7% of inspection-positive animals. Culture-positive animals had been positive at 70% by meat inspection, at 58.9% by SICCT and at 62.5% by IDEXX ELISA. Keeping in mind that these preliminary data include a bias due to selection of samples the data show that ELISA might be a reasonable method to detect a considerable percentage of bTB-suspect animals in high prevalence areas.

Polymerase Chain Reaction (PCR) Specificity Evaluation In The Identification Of Mycobacterium bovis
Azcatl-Camacho, A., Alfonseca-Silva, E., Gutiérrez-Pabello, J.A., Laboratorio de Investigación en Tuberculosis Bovina Microbiología e Inmunología, Facultad de Medicina Veterinaria y Zootecnia Universidad Nacional Autónoma de México, Distrito Federal, México

Mycobacterium tuberculosis (M. tb) and Mycobacterium bovis (M. b) are the causative agents of human and bovine tuberculosis respectively. Both species belong to the M. tuberculosis complex and have a DNA sequence homology over 99%. There are several PCR protocols published in the literature that reported high specificity for Mycobacterium bovis. However, when working with field strains it is hard to replicate the results. Here, we evaluate five PCR protocols designed to identify M. bovis by amplifying the following gene products: JB (M. b 500 bp), RD9 (M. b 206 bp and M. tb 333 pb), ESAT-6 (M. b and M. tb 169 bp), MPB-70 (M. b and M. tb 372 bp) and CFP10 (M.b and M. tb 210 bp). M. bovis specificity was assessed in a group of strains; M. b (33), M. tb (12), atypical mycobacteria (10), actinomycetes (4) and S. aureus (1). DNA of M. b AN5 and M. tb H37Rv was used as control. JB and ESAT-6 primers amplified M. b., M. tb, and actinomycetes, however only ESAT-6 amplified atypical mycobacterial strains. MPB-70 and RD9 primers amplified M.b and M. tb strains, however only RD9 was able to discriminate among species. In the case of CFP-10 primers amplification took place with M. b, M. tb, M. abscessus, M. kansasi, Trueperella pyogenes and other actinomycetes. In conclusion, specificity of M. bovis DNA PCR amplification was better accomplished using the RD9 protocol.

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Evaluation Of Methods For The Isolation Of *Mycobacterium bovis*
Yates, G.F., Bland, K.E., Joyce, M.A., de Lisle, G.W., AgResearch, National Centre for Biosecurity and Infectious Disease, Upper Hutt, New Zealand

Until recently the standard method used in our laboratory for isolating *M. bovis* from cattle and farmed deer was the liquid culture procedure using Bactec 12B medium. This method was sensitive and relatively fast, especially compared to those methods using solid media. Following the announcement that the manufacturer of Bactec 12B medium was going to stop producing it, trials were conducted to evaluate possible replacement culture methods. Alternative culture media evaluated included Mycobacteria Growth Indicator Tubes (MGIT), Middlebrook 7H9 broth supplemented with antibiotics and pyruvate, and pyruvate supplemented Mycobacteria 7H11 agar. The trials were conducted using tissue samples collected at abattoirs from cattle and farmed deer with macroscopic lesions resembling those caused by *M. bovis*. Samples (~1000) were homogenised, decontaminated with sodium hydroxide and then inoculated onto a range of different media. The media were compared on the level of contamination, their ability to isolate *M. bovis*, and the time for cultures to become positive. The level of contamination was not a problem for any of the media tested, including the liquid culture media. Compared to Bactec 12B, with MGIT there were fewer isolations of *M. bovis* and the time to positive culture was longer. However, when MGIT was coupled with a 7H11 pyruvate slope, the sensitivity for isolating *M. bovis* was comparable to that achieved with Bactec 12B.
A Cautionary Tale: A Case Study Of A Large, Movement-related TB Breakdown In A Dairy Herd In Northern New Zealand In Late-2012 and The Lessons Learned From This Breakdown
Sinclair, J., TBfree New Zealand, PO Box 3412, Wellington 6140, New Zealand

The presentation will discuss a high incidence dairy herd TB breakdown in the far north of New Zealand, in an area of low herd testing sensitivity due to negligible TB vector risk (the basis for New Zealand’s current herd testing framework).

The presentation will describe the consequences of “delayed disease diagnosis” and the various reasons for why this can occur. It will also describe the actions taken once the disease was diagnosed and the rapid progression towards clearance of infection in this herd. The significant benefits of the National Identification and Tracing (NAIT) scheme in resolving this outbreak will also be discussed.

The presentation will conclude with reaffirmation of the generally accepted principle that in any eradication scheme there needs to be a constant re-evaluation of policies to make sure that what is being done is still meeting the needs of that stage of the eradication scheme. As a country gets towards the end of an eradication strategy there is a need to look harder for disease as the prevalence drops.

A Potential Model For Assessing and Managing Herd Risks As Part Of A TB Control Programme
Sibley, R.J.1, Orpin, P.G.2,
1West Ridge Veterinary Practice, Witheridge, Devon EX16 8AS, UK
2Park Vet Group, 82-84 High Street, Whetstone, Leicester LE8 6LQ, UK

Introduction
A system of measuring and managing biosecurity and biocontainment risks as part of a comprehensive, farm specific disease management strategy for cattle farms for the prevention and control of Bovine Paratuberculosis (MAP, or Johnes Disease) has become established as a practical method of disease control in UK cattle herds.

Method
Disease risks were collected and assessed by a web based health management system (myhealthyherd.com). Herd disease status was then assigned using the results of strategic targeted surveillance. In a large scale funded project in South West England, those herds that were not infected were provided with a farm specific biosecurity plan to avoid infection, and infected herds were provided with a farm specific control plan that met their aspirations and available resources.

Results
Analysis of over 3500 cattle herds that have completed a biosecurity risk assessment for the specific risks associated with Johnes Disease show that 55% of the herds are at high risk of Johnes Disease (MAP) entering their herds, and only 15% can be regarded as secure. The risk assessment and management model has been shown to be popular with both farmers and veterinary surgeons, and has allowed practical biosecurity plans to be implemented on farms, specific to the risks that exist.

Conclusions
This paper will demonstrate that a popular, practical and effective structured system can be used to identify and manage herds at risk of disease before they become infected, as well as controlling disease in infected herds.
The Concept Of A Farm Advisory Service Evaluating Multiple Infectious Diseases In Order To Address Bovine TB Control On Farm

Paton, N.¹, Van Winden, S.¹, Erkelens, J.¹, Bishop, H.²,
¹Royal Veterinary College, Welsh Regional Veterinary Centre, College Farm, Gelli Aur, SA32 8NJ, UK
²Animal Health and Veterinary Laboratory Agency, 66 Ty Glas Road, Llanishen, Cardiff, CF14 5ZB, UK

Keywords
Bovine tuberculosis, cattle, infectious diseases, advisory service

The understanding of elements that contribute to spread of infectious diseases on farms could be vital in bTB control. The Welsh Government supported farm visits on farms with prolonged bovine tuberculosis (bTB) outbreaks in order to identify key factors involved in the current outbreak and prevent reintroductions. Farms experiencing a prolonged (>6 months) bTB breakdown were visited and a questionnaire was used to capture management techniques. Survival analysis methodology was used to determine the risk factors associated with length of breakdown. Both a univariate approach and a backward step wise analysis multivariate approach was taken.

Over 3 years 228 farms were visited in South Wales. In the multivariate model, factors that were associated with prolonged bTB outbreaks were: neighbouring herd bTB status, replacement policy, feeding wholecrop and, standard interpretation of bTB tests. Univariate factors were: gamma interferon testing, visiting markets and other premises, and total herd size. 168 farms were defined for BVD, IBR and leptospirosis status. IBR was most closely associated with prolonged bTB outbreaks.

The information in this study supports risk based trading, increased testing frequency, changing testing types, and supporting management changes on farm through veterinary advisory visits. Badgers had no effect on outbreak length but it is may be associated with new outbreaks. The association of IBR presence and a prolonged bTB breakdown suggests that bTB outbreaks could be prolonged due to an inability to control infectious disease. This study suggests that it is possible to give advice that will mitigate outbreaks in SW Wales.

Cymorth TB: Government and Private Vets Working Together To Improve Education and Support To Farmers In The Drive To Eradicate bTB

Enticott, G.⁶, Evans, L.¹, Huxtable, A.¹, Griffiths, R.², Lewis, M.¹, Lloyd, I.³, Rodgers, P.⁵, Stevenson, B.⁴, Ward, K.⁶, Williams, J.¹, Williams, S.¹,
¹Animal Health and Veterinary Laboratory Agency, Operations Directorate
²Office of the Chief Veterinary Officer, Department for Natural Resources and Food, Welsh Government, Cathays Park, Cardiff, CF10 3NQ, UK
³St James Veterinary Group, 253 Gower Rd, Swansea, West Glamorgan, SA2 9JL, UK
⁴Usk, Gwent, UK
⁵Allen & Partners, Millfield, Whitland, Carmarthenshire, SA34 0QN, UK
⁶Cardiff University, Glamorgan Building, King Edward VII Avenue, Cardiff, Wales, CF10 3WA, UK

Keywords
education and support, collaborative working, eradication

Introduction
The policy for TB eradication and management of disease at breakdown level is currently delivered by
government (AHVLA), with the majority of TB testing carried out by private veterinary surgeons (appointed as Official Veterinarians (OVs)). Cymorth TB was launched in December 2012 as a project to explore the provision of better support for farmers. The project has run a pilot to evaluate the benefits of collaborative working to this objective.

Materials and Methods
A pilot carried out in specified areas of Wales, between 1st October 2013 and 1st April 2014, to train OVs and engage them in bTB control measures, specifically using supplementary visits to new breakdowns. Evaluation of the project, including feedback from AHVLA, OVs and farmers, will include input from a social scientist.

Results and Discussion
It is recognised that the OV has local knowledge, an overview of the health of the breakdown herd and an established working relationship with the farmer.

Farmer compliance with disease control measures is essential for the eradication of bTB and the education and engagement of the OV will provide additional support to farmers, increase compliance and promote best practice.

Training OVs and encouraging collaborative working at the breakdown level will provide better informed decision-making in the drive to eradication.

This paper will consider the benefits of additional support to farmers, the effectiveness of providing OV input to the breakdown, the resilience of the OVs and the suitability of the training programme for OVs.

Advances In Monitoring Of Tuberculin Testing In The Irish bTB Eradication Programme, 2008 - 2013
Duignan, A.1, More, S.J.2, Good, M.1,

1Department of Agriculture, Food and the Marine, Kildare St, Dublin 2, Ireland
2Centre for Veterinary Epidemiology and Risk Analysis, University College Dublin, UCD School of Veterinary Medicine, Belfield, Dublin 4, Ireland

Key words
Bovine TB, Intradermal Tuberculin Test, Private Veterinary Practitioner

The Single Intradermal Comparative Tuberculin Test (SICTT) is the principle means of detection of infection in live animals in the Irish Bovine Tuberculosis (bTB) Eradication Programme. The test is subjective and prone to considerable individual variation in performance in the field. Private Veterinary Practitioners (PVPs) are responsible for the application of 95% of the testing in Ireland, amounting to circa 8 million animal tests per annum. Consistent application of the test in compliance with international requirements is critical to the success of the eradication programme and to providing security to importing countries. A specialist report using the Animal Health Computer System was introduced in 2008 to monitor the performance of each PVP in delivery of the SICTT. This report captures all data relevant to testing by each PVP and concentrates on measuring key deliverables that affect the quality of both administrative and disease detection performance. The key measures of performance are critical control points which were chosen because they are objective and readily measurable and enable comparison of PVP performance over time and between peers. It is now possible to give considerable attention to the standard of SICTT application on an objective basis. It is also possible to apply performance based sanctions or rewards based on analysis of the specialist reports. This presentation sets out the application of the performance reports and demonstrates improved delivery in the quality and reporting of testing since the introduction of the reports in 2008.
**Strategic Applications Of The IFNγ Assay In A Bovine Tuberculosis Eradication Programme**

Gormley, E.¹, Duignan, A.², Good, M.²,

¹Tuberculosis Diagnostics and Immunology Research, UCD School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland

²Department of Agriculture, Food & the Marine, Agriculture House, Dublin 2, Ireland

**Key words**

skin test, IFNγ assay, diagnostics, eradication, risk factors, PPD potency

The detection of early *Mycobacterium bovis* infection in cattle relies on the measurement of the cell-mediated immune responses and the most widely used field surveillance test is the tuberculin skin test. Arising from the need to increase the detection rate of *M. bovis*-infected animals in exposed herds, the interferon-gamma assay (IFNγ) was developed as an ancillary test to improve the sensitivity of testing of cattle when used in parallel with the tuberculin skin test, or to enhance specificity when used in series with the skin test. However, there are other applications of the IFNγ test that can be employed to assist in the management and eradication of *M. bovis* from infected herds. In Ireland, a full-herd SICTT is conducted annually on all cattle herds as part of the bTB eradication programme. Although recognised as an imperfect test at an animal level, its performance characteristics at herd level provides sufficient sensitivity and specificity for use as a disease surveillance test. In Ireland the IFNγ test is used in a variety of ways to enhance the tuberculosis eradication programme. In this presentation we will show how it is used: (1) as a highly sensitive ancillary diagnostic assay in exposed herds (2) as a quality assurance monitor of the efficiency of skin testing in exposed herds (3) to provide an understanding of risk factors associated with disclosure of true-and false-positive reactors (4) as a surrogate measure of tuberculin potency.

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**The Paradigm Shift: Adjusting The Livestock TB Testing Surveillance Programme Through the Lifespan Of A National Eradication Strategy; The New Zealand Experience**

Crews, K., TBfree New Zealand, PO Box 3412, Wellington 6140, New Zealand

The New Zealand TB strategy has progressed through various stages since the commencement of the original national programme in the late-1970s. Continual adjustments and improvements have been made to the livestock TB testing surveillance programme over a forty-year period from a broad-based, relatively simple set of testing specifications at the commencement of the programme, through to a targeted risk-based programme utilising GIS tools and decision-support systems in place now. A shift to a highly-refined, risk-based herd testing surveillance framework constructed around a variety of identified geographic, herd, animal, and farm risks (wildlife vector; movement; recrudescence; management) is being planned for New Zealand now that the eradication phase of the national strategy has commenced. The newly introduced National Identification and Traceability (NAIT) programme will become a key component of this latest refinement of the surveillance programme.

This presentation will detail the specifications of the New Zealand livestock TB testing surveillance programme at key stages during the period from the late-1970s through to 2013, how these have been refined over that period and the process by which these refinements were developed, agreed upon and implemented. The presentation will conclude with the vision for a highly-targeted, risk-based surveillance regime proposed for the eradication phase of the New Zealand TB strategy.
Application Of Electronic Animal Identification Systems For Tracing In Bovine TB Breakdowns

Hutchings, S.A., Livingstone, P., Crews, K., Sinclair, J., TBfree New Zealand, PO Box 3412, Wellington 6140, New Zealand

Keywords
bovine tuberculosis, National Animal Identification and Tracing (NAIT), TB breakdown investigation

Introduction
New Zealand has introduced through legislation a National Animal Identification and Tracing system. NAIT, the organisation that runs this system has merged with the Animal Health Board to form OSPRI New Zealand. This merge has allowed for the successful use of animal movement data in TB breakdown investigations on cattle and deer farms.

Methods
We will demonstrate how animal movement data has been applied in the tracing of source TB herds and mitigation of risk of further spread through effective trace forward of stock post infection.

Results and discussion
New Zealand has recently had a number of high profile TB herd breakdowns in herds, following movements of large numbers of cattle as part of the normal management of their dairy business. The ability to trace individual animal movements over time and display these geospatially has assisted in the successful back and forward tracing of infected stock reducing the time to clearance of infection and preventing establishment of disease in other herds.
Review Of Economics Used For bTB
Bennett, R., School of Agriculture, Policy and Development, University of Reading, Whiteknights, PO Box 237, Reading, RG6 6AR, UK

A brief review of economic and social science studies applied to bovine tuberculosis (bTB) is presented. As an example, the methods, analysis and findings of a study to assess cattle farmers’ attitudes to and willingness to pay (WTP) for a bovine tuberculosis (bTB) cattle vaccine, to help inform vaccine development and policy, is presented. A survey questionnaire incorporating contingent valuation (CV) and choice experiment (CE) methods was administered by means of telephone interviews to a stratified sample of 300 cattle farmers in annually bTB-tested areas in England and Wales. Farmers felt that bTB was a major risk for the cattle industry and that there was a high risk of their cattle getting the disease. The CE estimate produced a mean WTP of £35 per animal per single dose for a vaccine that is 90% effective at reducing the risk of a bTB breakdown and an estimated £55 for such a vaccine backed by 100% insurance of loss if a breakdown should occur. The CV estimate produced a mean WTP of nearly £17 per dose/per animal/per year for a vaccine (including 100% insurance) which, given the average lifespan of cattle, is comparable to the CE estimate. These WTP estimates are substantially higher than the expected cost of a vaccine which suggests that farmers in high risk bTB ‘hotspot’ areas perceive a substantial net benefit from such a vaccine.

Bovine Tuberculosis: The Costs Of The Eradication Plan In The Latium Region (Italy)
Scaramozzino, P.1, Caminiti, A.1, Battisti, S.1, Colafrancesco, R.1, De Giusti, M.2, Ficarelli, V.3, Gamberale, F.1, Mannocci, A.2, Pelone, F.2, Sala, M.1, Simeoni, S.1, La Torre, G.2, Della Marta, U.3,
1Istituto Zooprofilattico Sperimentale delle Regioni Lazio e Toscana – Rome, Italy
2“La Sapienza” University of Rome, Department of Public Health and Infectious Diseases, Rome, Italy
3Lazio Region, Rome, Italy

Key words
Bovine tuberculosis, eradication, cost

There is an increasing interest of European Institutions towards economical impact assessment of animal health control programmes. The implications of bovine tuberculosis (bTB) for Public Health and trade are well known. Notwithstanding the economic effort and political commitments of the European Union (EU), the eradication of bTB has not been achieved in Europe.

The aim of this study was to quantify the direct costs of the bTB eradication plan carried out in the twelve Local Health Units (LHU) of the Latium region from 2007 to 2011. The secondary objectives were the description of costs trend, and the relationship between the estimated costs and the EU co-funding.

The perspective of the regional government was adopted, by following a three-step procedure: identification and quantification of resources and attribution of the economic value. Three types of relevant resources were identified as follows: personnel, transportation and supplies. Data were collected mainly from official EU report and a face-to-face questionnaire submitted to the heads of the Veterinary Service of the LHUs.

The estimated cost over the whole study period was €5,814,210. We found that costs significantly decreased when a territory was declared disease-free, the personnel accounted for almost 90% of the total cost, and the EU co-funding covered 9.5% of the total cost.
Costs evaluation is a necessary step to implement a full economic analysis, and this study represents an evidence-based methodology applied in the field of Animal Health control.

Acknowledgments
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Veterinary Geography: Bovine TB Eradication In Northern Ireland
Robinson, P.A., Dept. of Geography, Science Laboratories, Durham University, S Rd, Durham, County Durham, DH1 3LE, UK

Keywords
bTB eradication programme; Human geography; Interdisciplinary research; Socio-economic; Socio-cultural

Introduction
Bovine tuberculosis (bTB) is a significant animal health problem in Northern Ireland (NI), and eradication remains elusive, despite an intensive statutory bTB programme which began in 1959. Having worked in various capacities within the programme as a private veterinary practitioner, government veterinary officer, official veterinarian, and veterinary epidemiologist, my postgraduate research in human geography explores why the bTB problem is yet to be resolved.

Materials and Methods
Based on ethnographic semi-structured individual and group interviews with farmers, vets and other stakeholders involved in the bTB programme, this research combines knowledge and insight from my experiences as both vet and human geographer to produce a veterinary geography of bTB.

Results
Whilst there are scientific, technical and ecological reasons for the failure to eradicate, socio-economic and socio-cultural factors have also had an influence on the success of the programme.

Discussion/Conclusion
Disease problems such as bTB at the society-nature interface are complex and often indeterminate, and my contention is that they benefit from interdisciplinary research which can provide critical analysis to explain why eradication has not yet been achieved. It is particularly important to understand the human attitudes and behaviours which affect the implementation and progress of disease control in the field.

Bovine Tuberculosis: An Economic Threat Or A Big Fuss About Nothing?
Torgerson, P., University of Zürich, Vetsuisse Faculty, Winterthurerstrasse 270 CH 8057 Zürich, Switzerland

With the exception of the legislative requirements the present bovine tuberculosis (bTB) elimination programme supports none of the aims claimed by Defra. The disease poses a minimal public health threat providing milk is pasteurised: human bTB is rare in the UK. Human bTB is also relatively uncommon globally, even in those countries that have no bTB controls. Clinical bTB in cattle is rarely observed in the UK, despite the fact that present diagnostic tests will not detect 20% of infected cattle resulting in several thousand of infected UK cattle routinely going undetected. The real economic cost of bTB is the costs of implementing the bTB programme, not the direct costs of the disease. With fatal accidents recently documented on both UK and Irish farms during routine TB tests it can also be argued that bTB control is a greater human health hazard than the disease itself. In terms of bTB, Defra admits “we cannot go on like this”. This is true, but the best way to save £100 million of public money spent annually on bTB control, alleviate the suffering of farmers adversely affected by bTB control and improve animal health and welfare.
is to abandon bTB control in the present form. This would require a change in legislation but would also
release substantial amounts of tax payers’ money to be used more productively in other areas of animal
or public health.

Social Research Methods Reveal Effective and Practical Management Interventions For Bovine Tuberculosis Management

Cowie, C., University of York, York, YO10 5DD, UK

Keywords
Stakeholder consultation, disease management interventions, bovine tuberculosis, best-worst scaling, social research, south-central Spain

Introduction
Livestock disease control strategies are usually determined at national and international levels, yet their
successful implementation is determined by stakeholders operating them on local scales. Such stakeholders
may also have detailed knowledge that would contribute to the development of disease controls that
are suited to the socio-cultural and environmental conditions where management is undertaken. Here,
we evaluate stakeholder’s opinions of potential bovine tuberculosis (TB) management interventions for
South-central Spain.

Materials and Methods
Research was conducted in South-central Spain, an area with high TB prevalence in wildlife and livestock,
where veterinarians, hunters and livestock farmers are all key stakeholders in TB management. A literature
review identified relevant bovine TB management interventions. The effectiveness of each intervention
was ranked by local experts, and practicality was ranked by hunters, cattle farmers and veterinarians, using
a best-worst scaling exercise.

Results
The most effective intervention, the banning of supplemental feeding of game species, was not considered
practical by stakeholders. The most effective and practical interventions were the separation of wildlife
and livestock access to waterholes, testing cattle every three months on farms with a recent positive TB
case and removing gut-piles from the land after hunting events.

Discussion/Conclusion
Each stakeholder group supported different approaches more strongly, suggesting that it might be effective
to promote different management contributions in different stakeholder communities. This integrated
approach contributes to the identification of the optimum combination of management tools that can be
delivered efficiently.

Farmers’ Beliefs and Bovine Tuberculosis In Cattle

Kaneene, J.B.1, Griffore, R.J.2, Phenice, L.A.3, Hakoyama, M.4,
1Center for Comparative Epidemiology, College of Veterinary Medicine, Michigan State
University, East Lansing, Michigan 48824
2Department of Human Development and Family Studies, College of Social Science, Michigan
State University. East Lansing, Michigan 48824
3Department of Human Development and Family Studies, College of Social Science, Michigan
State University, East Lansing, Michigan 48824
4Department of Human Environmental Studies, College of Education and Human Services,
Central Michigan University, Mt. Pleasant, Michigan 48859
**Keywords**

*M. bovis*, farmers’ beliefs, epidemiology

**Introduction**

This research examined selected risk factors, preventive measures, and beliefs associated with *Mycobacterium bovis* in cattle.

**Materials and Methods**

A four-page survey instrument was developed based on input from expert focus groups. The instrument was mailed to farmers in Midwest, U.S. with TB Positive herds, a Matching Control sample from TB positive areas, and farmers from areas that were TB Free was conducted. Descriptive statistics were computed, and group differences were examined using analysis of variance. Qualitative responses also were examined.

**Results**

Data from 31 respondents yielded insights about differences in beliefs and behaviours, between the three groups. Contrasts were noted in particular between the Bovine TB Positive group and the Matching Control group. Responses to the open-ended questions suggest that farmers have access to information and a limited understanding of how Bovine TB is transmitted. Regardless of the group, all seem to understand that cattle can acquire Bovine TB through contact with other animals. However, it is noteworthy that many known modes of transmission were not acknowledged by farmers in the TB Positive group.

**Discussion**

Evidence suggests that farmers’ beliefs are important factors to consider in preventive actions in order to control the transmission of Bovine TB. However, beliefs alone do not translate into behavioral differences that set the groups apart in considering preventive actions. These findings suggest implications for preventive solutions that are specific to the characteristics of a particular human ecosystem.

**Farmers’ Confidence In Badger Vaccination: A Longitudinal Analysis**

**Maye, D.**, Enticott, G., Fisher, R., Kirwan, J.

1*Countryside and Community Research Institute, University of Gloucestershire, Gloucester, GL2 9HW, UK*

2*School of Planning and Geography, Cardiff University, Cardiff, CF10 3WA, UK*

3*Royal Agricultural University, Cirencester, GL7 6JS, UK*

**Keywords**

Badger vaccination, Farmer confidence, Longitudinal analysis, Trust

**Introduction**

Badger vaccination has been proposed as a method that can help reduce the spread of bovine Tuberculosis (bTB) from badgers to cattle. In England and Wales, badger vaccination has been deployed in small-scale as part of government projects, by wildlife organisations, and farmers. Governments argue that badger vaccination is costly, impractical on a large scale and lacks evidence of a reduction in cattle bTB incidence. Wildlife organisations argue that badger vaccination is socially acceptable, avoids protest associated with badger culling, and is supported by farmers. Farmer views of badger vaccination are less well known. This paper analyses farmer confidence in badger vaccination.

**Materials and methods**

The paper draws on a longitudinal analysis of farmers’ confidence in badger vaccination in three areas of England, as part of a social science study that accompanies the Badger Vaccination Deployment Project.
Results
Farmers’ have low confidence in badger vaccination, which is associated with their levels of trust in Government. Longitudinal analysis is used to show how farmers’ confidence in badger vaccination has declined over time and how confidence in vaccination varies between farmers who are part of the Badger Vaccination Deployment Project, and those that are not. Factors affecting farmers’ confidence in vaccination are explored including farm type, disease prevalence, and perceptions of disease threat and self-efficacy. Moreover, the analysis suggests that farmers’ have deep-seated ideologies of nature and understandings of nature that lead them to reject vaccination in favour of other bTB control methods.

Discussion/Conclusion
Concludes with some comments on the relationship between trust and confidence.

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TB Testing In Private Practice: A Case Study Approach

Adam, K., Baillie, S., Rushton, J., The Royal Veterinary College, Hawkshead Lane, North Mymms, Hatfield, Hertfordshire, AL9 7TA, UK

Most bovine tuberculosis testing in Great Britain is currently carried out by private veterinary practices, which therefore play a central role in surveillance and control of bovine TB. The study explored how practices currently provide TB testing and how proposed policy changes may affect these businesses as part of a series of five detailed case studies of farm animal veterinary practices in Great Britain. The value of the case study approach lies in providing a detailed understanding of what is happening in real world situations.

Data were collected from each practice through a questionnaire, a semi-structured interview with the practice principal and additional follow-up via phone or email as required. Two case studies have been completed and three further case studies are planned.

Practice A is located in northern Scotland, which is officially free from TB, and therefore carries out minimal TB testing. The practice has experienced difficulties accessing support and training for vets carrying out TB testing. In contrast, practice B is located in an annual testing region in south west England. TB testing is therefore an important part of the practice’s workload and two dedicated TB testers are employed to enable the practice to fulfil its testing obligations.

Preliminary findings indicate that as resources have been focussed on TB endemic regions, government veterinary services in other areas have been negatively affected. The effect of proposed policy changes on private veterinary practices is likely to be highly variable and will depend on practice size, location and business model.