6 Molecular Epidemiology of *Mycobacterium bovis*

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6.1 Introduction

In 1998 the World Health Organisation (Cosivi et al. 1998) estimated that the incidence of human tuberculosis would be 88 million, resulting in 30 million deaths for the period 1990–1999 and the majority of cases would be in developing countries. In these countries, tuberculosis, caused by *Mycobacterium bovis*, is present in animals. However, surveillance and control programmes for animal tuberculosis in these countries are often inadequate or non-existent. Consequently, the epidemiology of *M. bovis* in public health issues remains largely unknown (Cosivi et al. 1998). *M. bovis* has an exceptionally broad host range that includes farmed and feral animals, wildlife and also humans (O’Reilly and Daborn 1995). Its epidemiological pattern in developing and developed countries can be very complex. It is classified as a List B disease by the Office International des Epizootiques (OIE) and considered of socio-economic importance as well as public health significance, as it impacts significantly on the international trade of animals and animal products and hence local livelihoods (Cousins 2001; Cousins and Roberts 2001).

6.2 Bovine Tuberculosis

Bovine tuberculosis is a chronic infection of animals, particularly cattle, and is caused by the tubercle bacillus *Mycobacterium bovis*. It is usually characterised by formation of nodular granulomas or tubercles, particularly in the lungs and in the lymph nodes of the respiratory tract but lesions also may occur in the mesenteric lymph nodes, liver, spleen and other organs. Presentation of the disease is variable with an absence of clinical signs in less advanced infection, often the case in the majority of infected cattle in developed countries with regular testing strategies (Neill 1994). It may also present non-specifically, with clinical signs such as weakness, anorexia, emaciation and coughing in advanced cases. In most countries diagnosis of tuberculosis in cattle is usually by tuberculin skin testing, measuring delayed-type hypersensitivity. However, in countries where prevalence of infection is extremely low or freedom from infection has been declared, meat inspection alone is employed for diagnosis and surveillance. More recently, application of assays for bovine interferon-γ has been employed to indicate infection (Neill et al. 1994). Supporting laboratory confirmation using bacteriological culture techniques is also often employed.

Bovine tuberculosis still can have serious, adverse, financial consequences in agricultural regions of the world (Bennett et al. 1999; Cousins 2001; Cousins and...
and is considered a potential human health risk in some countries (Cosivi et al. 1998). Farmers incur financial losses from decreases in meat and milk production, carcass condemnations and restrictions on animal movement. Bovine tuberculosis presents a serious barrier to cattle trade within and between countries and there is considerable expenditure, usually by governments, on testing and compensation. Most European countries, through the introduction of voluntary and subsequently compulsory eradication programmes, experienced dramatic success in reducing the incidence of bovine tuberculosis. However, despite initial progress, eradication has not yet been achieved in all countries (European Commission Report 1998). Some European countries, e.g., the United Kingdom, have considerable regional variability with sporadic outbreaks, particularly in South-West England and Northern Ireland.

Mycobacterium bovis infection in humans may result from ingestion of contaminated milk, inhalation via aerosols or through contact with infected clinical material. Pulmonary disease in humans, due to M. bovis is clinically, radiologically and pathologically indistinguishable from pulmonary tuberculosis caused by M. tuberculosis (O’Reilly and Daborn 1995). However, transmission of M. bovis from human to human is considered much less efficient than such transmission of M. tuberculosis (van Soolingen 2001). Evidence for transmission of M. bovis between humans is considered rare and largely anecdotal and equally rare are reports of humans infecting cattle (O’Reilly and Daborn 1995).

Mycobacterium bovis tuberculosis was once common in children, affecting the cervical lymph nodes, the intestinal tract or the meninges, as a result of feeding infected cows milk. By 1937 up to 25% of tuberculosis cases in the USA and UK were due to M. bovis infections (Cousins 2001). The introduction of pasteurisation for milk and milk products, together with abattoir meat inspections significantly reduced this incidence and bovine tuberculosis in children is currently negligible. It was the recognition of the public health risk that prompted the introduction of control and eradication programmes for bovine tuberculosis in many countries in the early part of the last century (Cousins 2001). The success of such schemes has resulted in a low prevalence, or absence, of M. bovis infection in most national cattle herds, particularly in countries with advanced agriculture practices. This was reflected in a dramatic drop in the incidence of human tuberculosis due to M. bovis. However, the zoonotic nature of M. bovis still places farmers, abattoir workers and veterinarians at risk (Grange 2001).

### 6.3 Epidemiology in Developed Countries

In developed regions of the world, several countries have been unable to eradicate this disease, despite rigorously implementing comprehensive and costly strategies. The primary route of infection for cattle is respiratory but alimentary infection, cutaneous, congenital and genital routes have been recorded (Neill 1994). Social behaviour of cattle in an environment of intensive farming and a high degree of live cattle trade, together with the potential of M. bovis survival on pasture and inanimate objects contribute to exposure and facilitate subsequent spread of infection (Morris et al. 1994). Many countries, previously endemic for bovine tuberculosis, have now been declared tuberculosis-free, following intensive test and slaughter policies (Cousins and Roberts 2001). However, where there is interplay between infected wildlife and domestic animals, control has proven problematic. It is now evident that better understanding of this disease and its epidemiology is essential to overcome the impeded progress in some countries.

Postulations on the residue of infection have included deficiencies in skin test specificity and sensitivity, poor cattle testing and the presence of reservoirs of M. bovis in cattle and wildlife. Traditional farming practices with significant cattle movement, intensive farming with high stocking densities and poor boundary fencing between farms allowing cattle ‘nosing’ between neighbouring farm herds have also been cited (Neill 1994; O’Reilly and Daborn 1995). In Ireland, inter-bovine spread of tuberculosis was identified as the single most important source of infection (Neill 1994). However, wildlife reservoirs are increasingly being considered a significant risk and responsible for protracted eradication programmes (Cheeseman et al. 1989; Livingstone 1992; Gallagher and Clifton-Hadley 2001). In the United Kingdom and Ireland, badgers (Meles meles) and feral deer (Cervus elaphus) are recognised wildlife reservoirs of M. bovis (Cheeseman et al. 1989; Hughes and Rogers 1994; Gallagher and Clifton-Hadley 2001). Badgers are indigenous and a protected species in the United Kingdom and Ireland with estimates in Great Britain of approximately 250,000 badgers, in Northern Ireland 30,000 (Hughes and Rogers 1994).