TUBERCULOSIS IN ANIMALS AND MAN

A Study in Comparative Pathology

by

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My book 'Bovine Tuberculosis' published in 1947, inevitably provided a basis for the present section on Bovine Tuberculosis, and I am indebted to Staples Press for their courteous permission to make use of the earlier account. The whole subject of avian tuberculosis, including infection of wild birds, and of mammals, with avian tubercle bacilli, has been very thoroughly and ably reviewed by Feldman (1938*a*) and his book was of much assistance when dealing with these subjects.

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INTRODUCTION

BOVINE tuberculosis is of great economic importance to the farming industry, and a serious danger to public health as man may be infected by direct inhalation of bovine tubercle bacilli, or by ingestion of infected milk and dairy products. The incidence of tuberculosis in cattle is described, and the methods of diagnosing, controlling, and eventually eradicating it are outlined. Already bovine tuberculosis has been virtually eradicated from Finland, the U.S.A., and the Scandinavian countries; and it is evident that its incidence will be reduced to very low levels in Great Britain, Canada, Australia, New Zealand, and probably several other countries within the next ten years.

The relationship of the three types of tubercle bacilli and of the human and bovine tuberculous epidemics are discussed. Infection of man with the bovine type of tubercle bacilli is described. A description of the so-called 'skin tuberculosis' of cattle, which is of importance because it sensitizes to tuberculin, is extended to include an account of somewhat similar conditions in buffaloes, and in man. The pathology, pathogenesis, and epidemiology of bovine tuberculosis are described, and tuberculosis in a variety of other animals and birds is dealt with in the later parts of the book.

Koch's original paper (1884) on the aetiology of tuberculosis contained a considerable amount of information on tuberculosis in animals. The first book on tuberculosis in man and animals was Straus's classical *La Tuberculose et son Bacille*, published in 1895. As Pinner says (1945, *552*): 'One is again and again amazed to find how relatively little has been added to the basic knowledge contained in this work.' Calmette's *L'infection Bacillaire et la Tuberculose*, 4th edition, revised by Boquet and Nègre, is a valuable source of information and contains excellent coloured illustrations of tuberculous lesions in various animals. Cobbett's *The Causes of Tuberculosis* (1917) is invaluable as a guide to the massive reports of the British Royal Commission on Tuberculosis. The Commission's numerous experiments, obviously performed with great care, carry more conviction than some of the recent work on tuberculosis, and these reports still represent the best source of information on many aspects of tuberculosis in animals; they did much to clarify the relationship of the three main types of tubercle bacilli. In order to facilitate reference to these reports their contents are included in an appendix. One feels that in the establishment of the Royal Commission's experimental farms and the planning of work, Sir John M'Fadyean's great knowledge of agriculture and animal pathology must have been invaluable.

Feldman (1938*a*) provided an admirable account of avian type infection, and Rich (1944 and 1951) wrote 'by far the most important book on the pathogenesis of tuberculosis'. In fact, it is more than a book on tuberculosis as it deals exhaustively with the whole question of infection and resistance. Rich's book inevitably contains much information about tuberculosis in animals, but it is not presented in such a way as to give a picture of the diseases in each species.

My purpose has been to provide a modern account of tuberculosis in all the species in which there is reliable information. Where large works have been cited the page number, in italics, has usually been included to facilitate reference. The information for each species is summarized on pages 101 and 275, and in the final chapter an attempt is made to present a closer comparison between the pathology and epidemiology of tuberculosis in man and animals than has previously been done, and to introduce some unifying concepts. Thus table 51 (p. 294) indicates that characteristic 'tubercles' occur only in animals that develop a fairly high degree of allergy. With smaller degrees of allergy lesions are less characteristic and there is no tubercle formation in rats and mice. It is also shown that the varying intrinsic toxicity of mycobacteria is profoundly modified by the degree of allergy produced in the different species (Table 52, p. 299) and that allergic sensitivity varies in different areas of the skin. Consequently some sites are much more suitable than others for performing the tuberculin test in the various species. Tables 55, 56 and 57 (pp. 305-308) show survival times of animals infected experimentally with virulent tubercle bacilli. They therefore provide a basis for assessing the virulence of other strains of bacilli.

The study of disease in the domestic animals is sometimes spoken of as comparative pathology, but when performed for its own practical ends it belongs to the field of veterinary medicine, just as the study of disease in man belongs to human medicine. It is only when a disease is studied in a variety of species, often including man, in an attempt to obtain a better understanding of the processes involved, that one may legitimately speak of comparative pathology. As Francis Bacon wrote, 'No one can justly or successfully discover the nature of any one thing in that thing itself, or without numerous experiments which lead to further inquiries'. Tuberculosis offers an ideal field for the application of the comparative method, and it is hoped that the account which follows will contribute to the better understanding of tuberculous disease as a whole and provide a general picture of the disease at a time when a determined effort is being made, in both the medical and veterinary fields, finally to overcome the infection. In this connection it is interesting to note that in my book on *Bovine Tuberculosis* published just ten years ago, I concluded that the disease would be practically eradicated from Great Britain in 30–40 years. The Attested Herds Scheme has now made such progress that it seems probable this goal will be reached in another ten years. The eradication of tuberculous infection from the human population is a much more difficult task but this aim is being more and more widely accepted as the ultimate objective.

This book arose following a request from Professor F. R. G. Heaf to prepare an account of Bovine Tuberculosis for inclusion in a Symposium on Tuberculosis. When this request was extended to cover tuberculosis in other animal species the material became too large for inclusion in the Symposium, and an abridged version was prepared and included in the *Symposium of Tuberculosis* published by Cassell and Company Ltd., in 1957. The publishers kindly agreed, however, to publish the full account as a separate work, and in order for this to be complete there is inevitably some repetition.

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CHAPTER I

THE INCIDENCE OF BOVINE TUBERCULOSIS

THE incidence of tuberculosis varies in different types and ages of cattle, and before describing the percentage of infected animals it will be useful very briefly to outline the natural history of the disease.

The striking fact about primary tuberculous infection in man is that as a rule lesions heal, giving rise to 'the familiar non-progressive globular little lesions of the primary complex'. Hence a large proportion of the population reacts to the tuberculin test but does not spread infection. It is the person with bronchogenic phthisis of the 'reinfection type' who chiefly spreads the disease. In cattle the position is quite different. Only about 10% of British cattle would have reacted to the tuberculin test in 1952, but almost all of these had open, though not acute, pulmonary tuberculosis of the bronchogenic type.

This difference between man and cattle has long been obvious, but our knowledge of bovine pulmonary tuberculosis has been put on a much firmer basis by Stamp (1948). It appears that when either calves or adult cattle become infected for the first time, by the aerogenous route, the result is usually a slowly progressive bronchopneumonia; and reinfection, either endogenous or exogenous, also gives rise to a bronchopneumonia. Calves that are housed with cows are exposed to a constant risk of infection by the aerogenous route, but when they are not housed with cows about 90% of them reach maturity (two years) without being infected. This is usually true even if they are pastured with cows, for the danger of infection at pasture is far less than in the cowshed. The risk of calves being infected by milk is not great, for only about 1% of tuberculous cows have tuberculosis of the udder: when it does exist, however, tuberculosis of the udder is a grave danger because if one cow has the disease it may infect all the calves fed on the mixed milk of the herd. Beef cattle are killed at two or three years of age, and figures obtained at meat inspection show that the incidence in these animals is only 5 to 15%. After parturition a heifer enters the cowshed and in many dairy herds she is exposed to heavy aerogenous infection during the rest of her life and the incidence rises steadily. Fig. 1 shows the average incidence of tuberculosis at various ages.

FACTORS INFLUENCING THE INCIDENCE OF TUBERCULOSIS

It is obvious that age influences the incidence of tuberculosis and it will be seen from

Fig. 1 that on the average in Europe it increases steadily from nearly 0 at birth to 35% at 5 years of age.

In 1905 42·8% of dairy cows supplying milk to Paris reacted to tuberculin and the following age incidence was found (Boquet and Nègre, 1936, *460*):

Age	No. tested	Percentage reactors
4 years and under	330	25·47
5 ,, ,, ,,	1,276	29·85
6 ,, ,, ,,	2,533	32·37
7 ,, ,, ,,	3,326	35·59
8 ,, ,, ,,	3,067	37·85
9 ,, ,, ,,	1,831	30·42
10 ,, ,, over	2,695	35·10

Straus (1895, *323*) gives the following data on age incidence based on abattoir statistics:

Age	No. Tuberculous	Percentage of Total
Under 6 months	208	0·4
6 months to 1 year	312	0·6
1 to 3 years	5,852	11·4
3 to 6 years	16,993	33·1
6 years and over	22,279	43·4

Moule (1948) tuberculin tested a stud herd of 847 cattle which ranged extensively over an area in Australia with an average annual rainfall of 10 inches. There were 13·1% reactors and when these were divided into age groups the yearly increase was similar to that shown in the lowest curve of Fig. 1. Autopsies on bulls indicated that infection was by the aerogenous route in 84% and it is thought that infection was acquired when animals congregated at waterholes and when 'playing and fighting'. Some herds on extensive properties reveal an even higher incidence of tuberculosis although in most the incidence is much lower. Thus in 15,000 dairy animals on the Darling Downs only 0·7% reacted and 300 of 360 herds were free from tuberculosis. A similar low incidence was found in some 6,000 dairy animals on the Atherton Tableland in North Queensland (Maunder, 1948, personal communication). These animals were Jerseys and Shorthorns and were brought into yards or sheds for milking although many were not fed in the sheds. It appears that there is quite a high incidence of tuberculosis in cattle under ranching conditions in South Africa (Robinson, 1953, see also p. 314).

It often causes some surprise that tuberculosis should reach any appreciable incidence in cattle on extensive properties, although it has been known since 1900 that the incidence may sometimes be high in cattle in Australia that are seldom or never housed (Francis, 1947). Again it is well known that pleuropneumonia may be a serious disease on extensive properties; and as pleuropneumonia is produced by droplet infection there is no reason