J. Hyg., Camb. (1986) **97**, 1–10
Printed in Great Britain

Tuberculosis in East Sussex

I. Outbreaks of tuberculosis in cattle herds (1964–1984)

By J. W. WILESMITH*, R. BODE†, D. G. PRITCHARD*, F. A. STUART* and P. E. SAYERS‡

** Epidemiology Unit and Bacteriology Department, Central Veterinary Laboratory, New Haw, Weybridge, Surrey KT15 3NB, † Animal Health Office, Medwyn House, Mountfield Road, Lewes, East Sussex BN7 2XJ and ‡ Wildlife and Storage Biology Discipline, Government Buildings, Coley Park, Reading, Berkshire RG1 6DT*

(*Received 19 November 1985; accepted 8 January 1986*)

SUMMARY

The history and epidemiology of bovine tuberculosis in cattle herds in East Sussex are described. Since 1960, following the compulsory eradication scheme for tuberculosis, the incidence of herd infection has been low. The epidemiological features of herd infection have been sporadic incidents, with only small numbers of cattle becoming infected in the majority of incidents. There was no evidence of endemic *Mycobacterium bovis* infection in the cattle population in East Sussex in recent years, but a low risk of infection for cattle on the South Downs, from badgers, was apparent.

INTRODUCTION

During the last 20 years there has been a steady decline in the number of cattle herds in the county, from 2537 in 1964 to 1452 in 1984. This is a reduction of 40 % compared with the reduction of 6·5 % in the number of cattle, indicating an increase in the average herd size. The number of dairy herds has decreased from 1392 to 359 during this period.

Sheep farming is common in the east of the county, where a large number of sheep graze part of Romney Marsh. The county is also an important poultry producing area.

The compulsory area eradication scheme for tuberculosis in cattle, initiated in 1950, has been described in detail by Evans & Thompson (1981). East Sussex was subjected to compulsory eradication in March 1958 and 143 herds not participating in any of the voluntary schemes were put under the statutory movement restrictions and subjected to the tuberculin test. These herds comprised 1602 cattle and no reactor to the tuberculin test was found in 93 herds; 222 reactors were disclosed in the other 50 herds at the first tuberculin test. Reactors were found in 12 of these herds at the second tuberculin test, but at the third tuberculin test no reactor was found.

East Sussex became part of the Attested Area in October 1958 when only 42 herds in the county had not attained attested status, i.e. had two consecutive official tuberculin tests at which no reactor was found. These 42 herds had all passed one tuberculin test.

By the end of 1958 there were also 2771 attested herds within the voluntary attested herds scheme and tuberculin testing of 74825 cattle revealed 175 reactors (0·2 %). The number of compulsory and voluntary attested herds had increased to 2859 by the end of 1959 and during that year 136 reactors (0·13 %) had been found in 106526 animals tested. Sixty-five reactors were disclosed in 31 (1·3 %) of the 2393 herds tested in 1961, representing 0·06 % of animals tested compared with 0·162 % in Great Britain. The percentage of animals reacting to the tuberculin test was reduced to 0·03 % in 1962 when 1 of the 20 infected herds was found to have been infected with *Mycobacterium tuberculosis* from a tuberculous stockman. A slight increase in the proportion of animals reacting to the tuberculin test (0·065 %) occurred in 1963 but this was comparable with that for Great Britain (0·068 %).

The success of the compulsory area eradication scheme in reducing the incidence of cattle infection to a very low rate in Great Britain was therefore shared by East Sussex. During the following decade it became evident that cattle herds in certain areas of the south-west of England, particularly in Gloucestershire and Cornwall, were experiencing relatively higher rates of infection. No source of infection was detected for herds in these areas until 1971 when a badger infected with *M. bovis* was found on a farm in Gloucestershire where the cattle had recently been infected (Muirhead, Gallagher & Burn, 1974; Report, 1976). Subsequent studies have provided evidence to substantiate a causal relationship (Report, 1979; Little *et al.* 1982; Wilesmith, 1983).

The Ministry of Agriculture, Fisheries and Food (MAFF) examined badger carcasses found by members of the public throughout Great Britain for evidence of *M. bovis* infections since 1971. In addition, badger faeces from a number of areas including East Sussex have been examined bacteriologically. Evidence of *M. bovis* infection in badgers in East Sussex was first obtained in 1976 as a result of the bacteriological examination of faeces samples (Report, 1976). Subsequent investigations have shown badgers to be a source of infection for cattle herds in one area of East Sussex (Report, 1982).

This paper describes the history and epidemiology of tuberculosis in cattle in East Sussex since 1963, and the following three papers describe the results of epidemiological and ecological studies on badger populations and other mammals in the county.

MATERIALS AND METHODS

Study areas

The main area of interest in East Sussex, because of the incidence of tuberculosis in cattle, is bounded by the sea to the south, the river Cuckmere to the west, Eastbourne to the east and the A27 (Lewes/Polegate) road to the north, an area of some 5500 hectares. It comprises mainly open chalk downland which is part permanent pasture and part arable. There are areas of scrub, which is dense in places, with a number of small woods and a larger area of woodland. This area will be referred to as the main area.

More detailed studies were carried out in an area of some 400 hectares on the northern edge of the South Downs. This area is bounded to the north by a main road, to the west by a village and to the east by urban development; the southern boundary is defined for part of its length by a minor road and partly by a sharp transition from downland into arable fields. This smaller area will be referred to as the project area.

Approximately half the project area lies on the scarp slope of the Downs (Middle Chalk) with a north-eastern aspect, falling sharply from 200 m above sea level to 50 m. The lower ground is fairly flat, and consists mainly of upper Greensand and Lower Chalk with areas of valley gravel and gault clay. The steeper slopes are covered by chalk downland permanent pasture, while less steep slopes carry improved grassland pasture and the flatter land grows arable crops – mainly winter cereals. Field boundaries are mainly barbed-wire fences but there are some hedges on the flatter land in the northern part of the area. There are many areas of scrub and several small woods. In the centre of the area lies a small village composed of houses and gardens, several small paddocks and an area of parkland. Apart from the roads which define the boundary of the area, there are a few farm roads and the area is well supplied with footpaths and bridleways.

At present this area is grazed in part by four cattle herds with a total stock of approximately 330 animals.

Tuberculin testing regime

Weybridge avian purified protein derivative (PPD) and human PPD were used in the intradermal tuberculin test as described by Ritchie (1953) until 1975. Subsequently, Weybridge bovine PPD was used in place of human PPD as described by Lesslie & Hebert (1975).

In 1964 all cattle herds in the county were compulsorily tuberculin tested. From 1965 to 1973 all herds were tested biennially and since 1974 triennial testing has been carried out. However, in certain areas, where the risk of herd infection was apparently increased, more frequent tuberculin testing was carried out and producer retailer herds, from which untreated milk was sold, were subjected to annual tuberculin tests.

Animals which were positive to the test were examined post-mortem and tissues with lesions typical of tuberculosis on gross examination sent for laboratory examination. If no lesion was observed a pool of the mesenteric, broncho-mediastinal, retropharyngeal and any other enlarged or haemorrhagic lymph nodes was submitted for laboratory examination.

In addition to the routine tuberculin testing of cattle a slaughterhouse monitoring system was in operation. Lesions in animals suspected of being tuberculous at routine meat inspection were subjected to bacteriological and histopathological examination, and if *M. bovis* infection was confirmed the herd of origin was traced and tuberculin tested.

Each herd in which *M. bovis* infection was confirmed was subjected to two tests at 60-day intervals followed by a test 6 months later and again after a further 12 months. If reactors were found at any of these tests, the testing regime was reimposed from the beginning. When the herd had reached freedom from infection at the 12-month test it reverted to the routine testing frequency in operation in

the area. These herds were subjected to restrictions on the movement of cattle on and off the farm until two consecutive tuberculin tests without reactors being found had been carried out.

A new incident of herd infection was defined as a herd in which infection had been disclosed following freedom from reactors to the tuberculin test for a period of at least 15 months.

Cattle populations

Estimates of the cattle population present in the county and these areas, during the period 1964–84, were obtained from the annual agricultural censuses and records obtained during the course of the tuberculosis control scheme.

Investigations to identify the source of infection

Following the disclosure of *M. bovis* infection in a herd an investigation is carried out to determine the source of infection. This investigation initially determines the possibility of infection having been introduced by the purchase of animals or by temporary contact with animals from other herds, e.g. hiring a bull, or cattle straying on to or off the farm. Where such events have occurred the herds from which animals have been purchased or the herds or animals which may have been in contact are tuberculin tested.

If such a source of infection is eliminated, the likelihood of infection having been acquired from other animals such as pigs, goats, dogs and cats is examined. Also the possibility of infection having been contracted from humans either directly, e.g. from farm staff, or indirectly by contact with sewage effluent is investigated.

Since 1976, where these investigations have failed to identify a source of infection, the possibility of infected badgers as a source of infection has been considered, as described by Zuckerman (1980). The source of infection for cattle was attributed to badgers where the range of an infected badger population was known to be coincident with the area occupied by the cattle.

Laboratory methods for the diagnosis of tuberculosis in cattle

A portion of any lesions found was fixed in 10% buffered formalin for histopathological examination using sections stained by the Ziehl–Neelsen method and with haematoxylin and eosin. The remainder of any lesion present and a portion of each lymph node in the pooled specimen were ground up using a sterile pestle and mortar with sterile sand. The tissues were decontaminated using 5% oxalic acid, and examined culturally and biologically. The culture media used were Stonebrink's medium (Lesslie, 1959), Lowenstein–Jensen alone, with glycerol and with pyruvate (Holm & Lester, 1942) and either blood medium (Birn, 1965) or modified Middlebrook and Cohn's 7H11 medium (Gallagher & Horwill, 1977). Biological tests in guinea-pigs were carried out; their tissues were subcultured if they showed sensitization to mammalian PPD 5 weeks post-inoculation or lesions of tuberculosis at post-mortem examination, when no primary isolation of *M. bovis* was obtained on direct culture of the bovine tissues.

The isolates were identified as *M. bovis* according to the criteria described by Little *et al.* (1982) and Marks (1976).

Visible lesions of tuberculosis were defined as those with gross pathology

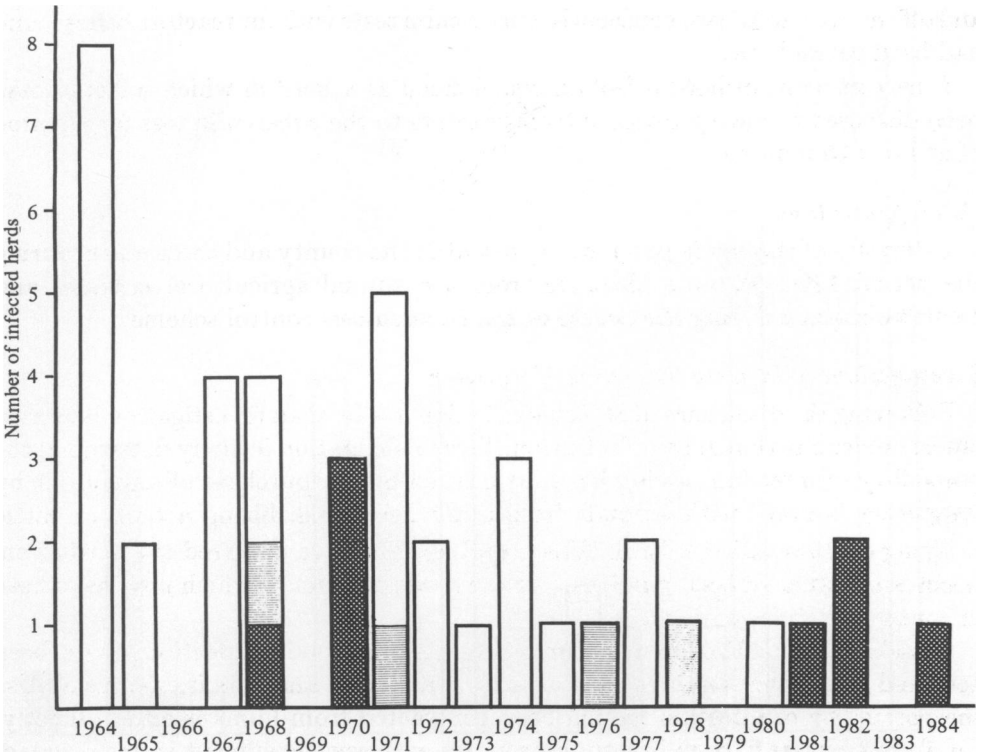

Fig. 1. Number of herds infected with *M. bovis* in East Sussex 1964–84. □, herds in East Sussex excluding the main area; ▤, herds in the main area excluding the project area; ▨, herds on farms with grazing land in the project area in 1984.

resembling tuberculosis (Jubb & Kennedy, 1970) from which *M. bovis* was subsequently isolated.

RESULTS

Bovine tuberculosis in East Sussex

The number of herds with confirmed *M. bovis* infection in each year during the period 1964–84 is shown in Fig. 1 and the number of cattle with confirmed infection disclosed in Fig. 2.

The sources of infection attributed to new incidents of infection during the period 1966–84 are shown in Table 1.

A slight increase in the incidence of cattle infection compared with the previous 2 years occurred in 1964, but this was not sustained in subsequent years. Sporadic incidents of herd infection have, however, continued to occur; animals with confirmed *M. bovis* infection were found in each year except 1966, 1969, 1979 and 1983.

The within-herd prevalence of infection has been low, the majority of herds only suffering one or two infected individuals.

Four herds suffered two new incidents of infection, in 1972 and 1974, but with

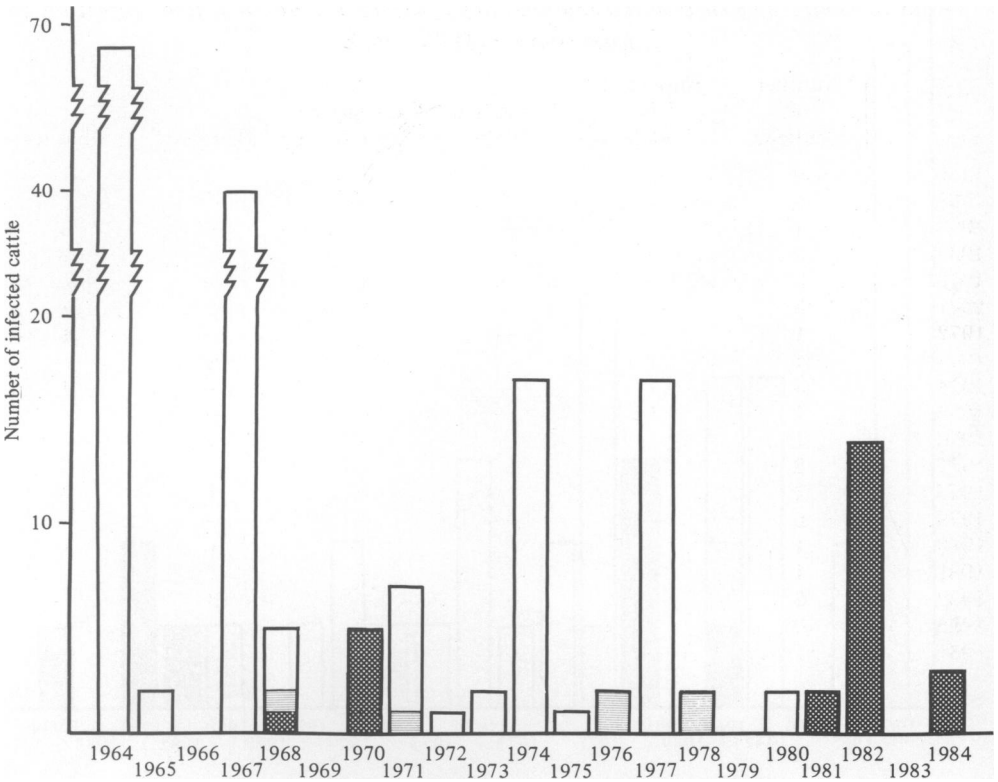

Fig. 2. Number of cattle infected with *M. bovis* in East Sussex 1964–84. □, animals in East Sussex excluding the main area; ▤, animals in the main area excluding the project area; ▨, animals on farms with grazing land in the project area in 1984.

no attributable source of infection. One of these is now located in West Sussex as a result of county boundary changes in 1976. (Two other herds which became infected are also located in West Sussex since the county boundary change.) No source of infection was identified for two of the other three herds, one of which ceased to exist in 1978. The remaining herd became infected on both occasions as a result of the purchase of Irish animals, the last incident being in 1974. No herds have become infected as a result of the importation of infected Irish cattle since 1975.

The majority of herds which have become infected since 1975 were in the main area, and since 1980 all have been in the main area. Fig. 3 depicts the geographical distribution of infected herds and their source of infection during the period 1966–84. Herds with infected badgers attributed as a source of infection have been confined to the South Downs in the south-west of the county, and the four herds infected since 1981 have been associated with infected badgers.

Histories of farms with cattle in the project area

The four cattle herds on farms currently with grazing land in the project area remained free from infection from 1958 until 1981 when the annual check

Table 1. *Sources of infection attributed to confirmed incidents of herd infection in East Sussex (1966–1984)*

Year	Number of incidents	Import of Irish cattle	Purchased cattle	Contiguous premises	Badgers	Obscure
1966	0	—	—	—	—	—
1967	4	2	1	—	—	1
1968	4	—	—	1	—	3
1969	0	—	—	—	—	—
1970	3	—	—	—	—	3
1971	5	—	4	—	—	1
1972	1	—	—	—	—	1
1973	1	1	—	—	—	—
1974	3	1	—	1	—	1
1975	1	1	—	—	—	—
1976	1	—	—	—	1	—
1977	2	—	1	—	1	—
1978	1	—	—	—	1	—
1979	0	—	—	—	—	—
1980	1	—	—	—	1	—
1981	1	—	—	—	1	—
1982	2	—	—	—	2	—
1983	0	—	—	—	—	—
1984	1	—	—	—	1	—

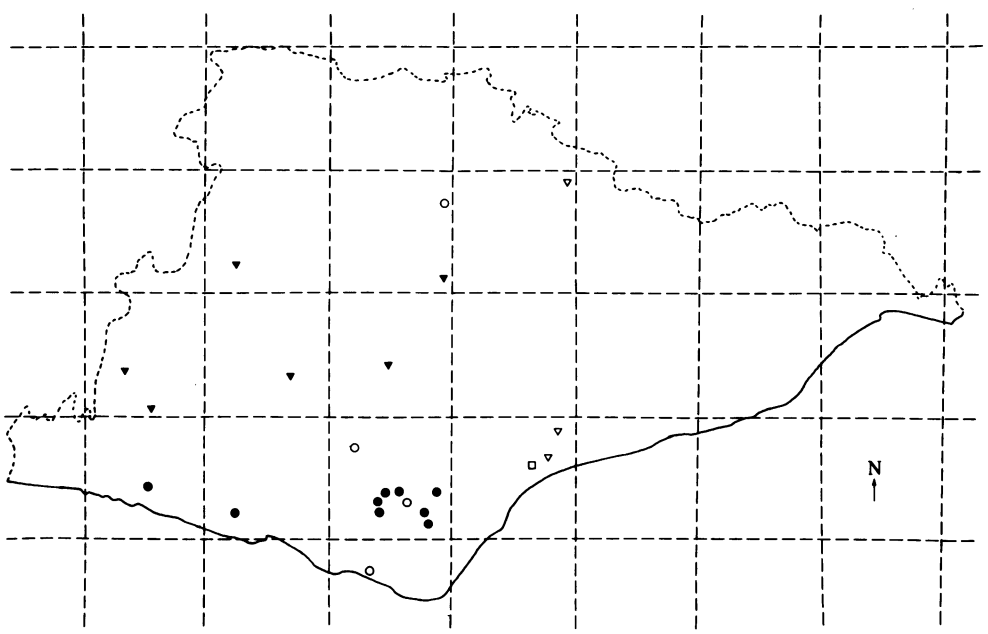

Fig. 3. Geographical distribution of herds with confirmed *M. bovis* infection, by source of infection, in East Sussex, 1966–84. ▼, purchased cattle; □, contiguous premises; ▽, Irish cattle; ●, badgers; ○, unknown. Dashed lines delineate 10 × 10 km squares.

tuberculin test of one herd in November 1981 revealed two reactors, aged 21 months, out of 136 animals tested. On post-mortem examination one animal had lesions in the retropharyngeal lymph nodes, the other animal had no visible lesion (NVL) but *M. bovis* was isolated from both animals. Subsequently, the annual check tuberculin test of a contiguous herd in February 1982 revealed two reactors aged 24 months out of 80 animals tested, both with visible lesions in the retropharyngeal lymph nodes, and *M. bovis* was isolated from both. Further check tests on both these herds did not reveal reactors, and since then no reactor has been found. In addition to these two infected premises, an annual check of a further contiguous herd in January 1982 revealed two reactors aged 22 months out of 407 animals tested. On post-mortem examination visible lesions were found in the retropharyngeal lymph nodes of one animal, the other animal had no visible lesion. Two further animals were then slaughtered as inconclusive reactors, based on severe interpretation, and both had visible lesions in the retropharyngeal lymph nodes. *M. bovis* was recovered from all four animals including the NVL reactor. At the next 60 day interval test 7 reactors were found in the original group of 15 22- to 24-month-old bullocks, making a total of 11 reactors which were slaughtered together with the remaining 4 in-contact animals. On post-mortem examination all 7 reactors had visible lesions, 6 with retropharyngeal lymph node lesions, and 1 with bronchial lymph node lesions. One in-contact had retropharyngeal lymph node lesions. *M. bovis* was isolated from animals with visible lesions. Therefore 12 of the original group of 15 bullocks were infected with *M. bovis*, of which 11 showed visible lesions of tuberculosis. Further check tests at these premises were clear until a check test of cattle was carried out in July 1984 because of known contact with tuberculous badgers in March and April of that year. This test revealed one heifer reactor aged 21 months but no visible lesion was found on post-mortem examination. *M. bovis* was isolated however from the lymph nodes. A further tuberculin test in October 1984 revealed two more 24-month-old heifer reactors which had visible lesions of tuberculosis, due to *M. bovis*, in their retropharyngeal lymph nodes.

DISCUSSION

The compulsory eradication scheme for tuberculosis was extremely succesful in East Sussex, as in the remainder of Great Britain. However, the scheme has disclosed the badger as a source of infection for cattle in the county (Wilesmith *et al.* 1986).

The incidence of herd infection from any source, since 1960, has however remained low and is comparable to other counties outside the south-west region of England (Zuckerman, 1980). The absence of herd infection as a result of the importation of infected Irish-bred cattle indicates the effect of the introduction of pre-export testing on these animals in 1976 noted by Rees (1981), which has been sustained throughout Great Britain (Wilesmith, 1985, unpublished findings).

The current epidemiological feature of herd infection in Great Britain has been sporadic incidents (Wilesmith, 1983). This has also been evident in East Sussex, with the majority of herds suffering only one incident of infection.

Unfortunately, the length of time badger populations in Great Britain have been infected cannot be determined, but the occurrence of incidents of herd infection

during the 1960s, with no attributable source of infection, in areas of high badger density in south-west England suggests that badger populations were infected at this time (Report, 1972). It seems possible that the three herds in the south-west quadrant of East Sussex which became infected before 1976 and with no attributable source of infection were infected by badgers. If this were so then the badger populations in this area have been infected since 1968, if not earlier.

The majority of incidents of infection arising from infected badgers in Gloucestershire in 1978 have only involved a small number of cattle (Wilesmith, 1983). This has recently been confirmed for all areas subject to annual tuberculin testing during the period 1979–83 (Wilesmith, unpublished findings). This epidemiological aspect of herd infection from badgers has been apparent in East Sussex. The frequency of tuberculin testing will have some effect on the number of cattle which become infected during an incident, the transmission of *M. bovis* within a herd being curtailed more rapidly in annually tested herds than in less frequently tested herds. However, these findings suggest a relatively small number of index cases in each herd, and the apparently low risk of cattle becoming infected from badgers is therefore evident (Little, Naylor & Wilesmith, 1982; Wilesmith, 1983). The infected herd revealed in January 1982 in the project area, in which 12 animals became infected, may have experienced a particularly high exposure to *M. bovis* from badgers, but the presence of potentially infectious cattle during this incident suggests that cattle-to-cattle transmission could have started.

Cattle at pasture are apparently most at risk (Muirhead, Gallagher & Burn, 1974), but the mode of transmission of *M. bovis* from badger to cattle is unknown. The potential sources of *M. bovis* for cattle exposed to an infected badger population have been discussed by Little, Naylor & Wilesmith (1982), and the distribution of lesions in cattle in one herd infected by badgers suggested that transmission via the respiratory route had occurred (Wilesmith *et al.* 1982). The relatively high proportion of infected cattle, in the project area, with lesions in the lymph nodes of the respiratory tract suggests that inhalation was also the predominant route of transmission in these herds.

The results of these analyses suggest that *M. bovis* is no longer endemic in the cattle population of East Sussex, but there is a low risk of infection for cattle on the South Downs from badgers.

The authors are indebted to staff in the Bacteriology Department and Epidemiology Unit for their technical support and in the Animal Health Office, Lewes, for assistance in abstracting information from the records. We would also like to thank Mrs Shirley Moody for typing the manuscript.

REFERENCES

Birn, K. J. (1965). Blood medium for the isolation of tubercle bacilli. *British Veterinary Journal* **121**, 437–441.

Evans, H. T. J. & Thompson, H. V. (1981). Bovine tuberculosis in Great Britain. I. Eradication of the disease from cattle and the role of the badger (*Meles meles*) as a source of *Mycobacterium bovis* for cattle. *Animal Regulation Studies* **3**, 191–216.

Gallagher, J. & Horwill, D. M. (1977). A selective oleic acid albumin agar medium for the cultivation of *Mycobacterium bovis*. *Journal of Hygiene* **79**, 155–160.

HOLM, J. & LESTER, V. (1942). Diagnostic demonstration of tubercle bacilli: comparison between cultivation and inoculation of guinea pigs. *Acta Veterinaria Scandinavica* **16**, 310.

JUBB, K. V. F. & KENNEDY, P. C. (1970). Pathology of Domestic Animals, vol. 1, pp.233–248. New York and London: Academic Press.

LESSLIE, I. W. (1959). A comparison of biological and some cultural methods for the primary isolation of *Mycobacterium tuberculosis*. *Journal of Comparative Pathology* **69**, 1–10.

LESSLIE, I. W. & HEBERT, C. N. (1975). Comparison of the specificity of human and bovine tuberculin PPD for testing cattle. 3. National trial in Great Britain. *Veterinary Record* **96**, 338–341.

LITTLE, T. W. A., NAYLOR, P. F. & WILESMITH, J. W. (1982). Laboratory studies of *Mycobacterium bovis* infection in badgers and cattle. *Veterinary Record* **111**, 550–557.

LITTLE, T. W. A., SWAN, C., THOMPSON, H. V. & WILESMITH, J. W. (1982). Bovine tuberculosis in domestic and wild mammals in an area of Dorset. II. The badger, its ecology and tuberculosis status. *Journal of Hygiene* **89**, 211–224.

MARKS, J. (1976). A system for the examination of tubercle bacilli and other mycobacteria. *Tubercle, London* **57**, 207–225.

MUIRHEAD, R. H., GALLAGHER, J. & BURN, K. J. (1974). Tuberculosis in wild badgers in Gloucestershire: epidemiology. *Veterinary Record* **95**, 552–555.

REES, W. H. G. (1981). *Nature* **290**, 263.

REPORT (1972). *Inquiry into Bovine Tuberculosis in West Cornwall*. Ministry of Agriculture, Fisheries and Food, London.

REPORT (1976). *Bovine Tuberculosis in Badgers*. Report by the Ministry of Agriculture, Fisheries and Food, London.

REPORT (1979). *Bovine Tuberculosis in Badgers*. Report by the Ministry of Agriculture, Fisheries and Food, London.

REPORT (1982). *Bovine Tuberculosis in Badgers*. Report by the Ministry of Agriculture, Fisheries and Food, London.

RITCHIE, J. N. (1953). Control of bovine tuberculosis in cattle. In *Advances in the Control of Zoonoses*, pp. 25–34. *Monograph Series of the World Health Organization* no. 19. Geneva: WHO.

WILESMITH, J. W., LITTLE, T. W. A., THOMPSON, H. V. & SWAN, C. (1982). Bovine tuberculosis in domestic and wild mammals in an area of Dorset. I. Tuberculosis in cattle. *Journal of Hygiene* **89**, 195–210.

WILESMITH, J. W. (1983). Epidemiological features of bovine tuberculosis in cattle herds in Great Britain. *Journal of Hygiene* **90**, 159–176.

WILESMITH, J. W., SAYERS, P., BODE, R., PRITCHARD, D. G., STUART, F. A. & BREWER, J. I. (1986). Tuberculosis in East Sussex. II. Aspects of badger ecology and surveillance for tuberculosis in badger populations (1976–1984). *Journal of Hygiene* **97**, 11–26.

ZUCKERMAN, LORD (1980). *Badgers, Cattle and Tuberculosis*. London: Her Majesty's Stationery Office.