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Bovine tuberculosis in domestic and wild mammals in an area of Dorset. III. The prevalence of tuberculosis in mammals other than badgers and cattle

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SUMMARY

A large sample of the wild mammals found on a farm in South Dorset were trapped and examined for the presence of *Mycobacterium bovis* following the discovery of widespread infection in cattle and badgers. *M. bovis* was isolated from the lymph nodes of two out of 90 rats (*Rattus norvegicus*) and one out of seven foxes (*Vulpes vulpes*) but no lesions of tuberculosis were observed. It was concluded that the badger was the only species of wild mammal which was a reservoir of *M. bovis* in this area.

INTRODUCTION

Tuberculosis caused by *M. bovis* has been described in many species of domesticated and free-living animals, but the prevalence was usually very low when compared with cattle and was found only where domestic animals were closely associated with tuberculous cattle (Francis, 1958).

The prevalence of tuberculosis in sheep has always been very low in Britain and in most parts of the world (Francis, 1958). Huitema (1972) stated that sheep were not very susceptible to tuberculosis and pointed out that even when sheep graze the same pasture as heavily infected cattle they rarely showed tuberculous lesions at post-mortem examination. *M. bovis* has been isolated from feral sheep in New Zealand (Stockdale, 1975).

In contrast, pigs are very susceptible to *M. bovis* (Francis, 1958) although there is little evidence that the infection spreads from pig to pig in Britain. Tuberculosis in pigs caused by *M. bovis* rapidly disappeared when the disease was controlled in cattle although cases due to *M. avium* are still found (Lesslie *et al.* 1968). Schroeder & Mohler (1906) found that pigs would become infected by ingesting the infected faeces containing maize from cattle infected with bovine tuberculosis and considered this to be a very important mode of infection.

The literature on tuberculosis in cats and dogs was reviewed by Francis (1958) and more recently by Snider (1971). Bovine tuberculosis used to be fairly common in cats in Britain and was closely associated with the presence of bovine tubercle

bacilli in raw milk and slaughterhouse refuse (Francis, 1958). For example Jennings (1949), in a study in Liverpool, reported that 13% of cats were affected with tuberculosis. Tuberculosis in dogs has more frequently been associated with *M. tuberculosis* than *M. bovis* because dogs have much closer contact with man.

Recently, two cases of tuberculosis in cats have been reported in Britain (Orr, Kelly & Lucke, 1980). In Pennsylvania, Snider *et al.* (1971) studied cats and dogs exposed to cattle affected with bovine tuberculosis. *M. bovis* was isolated from four out of nine dogs and 12 out of 52 cats, suggesting that cats and dogs might be involved to a greater extent than generally believed in the epidemiology of bovine tuberculosis at the stage of eradication they had reached in the United States.

Tuberculosis in free-living wild animals has been reviewed by Francis (1958), McDiarmid (1962), Rankin & McDiarmid (1968) and Huitema (1972). These authors found little published information on bovine tuberculosis, although tuberculosis of voles in Britain is well recorded.

The presence of tuberculosis in wild voles in Britain was first reported by Wells (1937), who called the organism he isolated the vole acid-fast bacillus (Wells, 1946). It is now classified as *Mycobacterium microti* (Reed, 1957). He subsequently identified the condition in 19 locations in Britain in more than 900 small mammals of four species: the field vole (*Microtus agrestis*), the bank vole (*Clethryonomys glareolus*), the wood mouse (*Apodemus sylvaticus*) and the common shrew (*Sorex araneus*). Despite the widespread occurrence of *M. microti* in Britain there is no reference to its isolation since 1939, and there is no record of *M. bovis* being isolated from mice, voles or shrews although the vole is very susceptible to *M. bovis* infection (Griffiths, 1939; Jespersen, 1975).

Bosworth (1940) reported the isolation of *M. bovis* from two rats caught in England which showed no lesions at post-mortem examination. Plum (1942) in Denmark, however, isolated *M. avium* from 16·5% of 640 rats caught in Copenhagen. The brown rat (*Rattus norvegicus*) was described by Francis (1958) as the most resistant of all animals to tuberculosis. Inoculation of very large numbers of *M. bovis* produced no lesions, but early workers found that feeding infected material to rats led to the presence of large numbers of organisms in the mesenteric lymph nodes but not to the formation of lesions. Griffiths (1939) described one isolate from a hedgehog as being a fully virulent bovine bacillus. The hedgehog had died from pneumonia with regions of grey hepatization of the lung containing large numbers of acid-fast bacilli. *M. bovis* has also recently been isolated from hedgehogs in New Zealand (Stockdale, 1975) but the number was small and they were not considered to be an important source of infection to cattle. A strain of *M. avium* has been isolated from one of five hedgehogs examined by Matthews & McDiarmid (1977).

Francis (1958) claims that in spite of its great susceptibility to bovine tuberculosis no authenticated case has been reported in a wild rabbit. However, a case has recently been described in a rabbit in New Zealand where the infection originated from a bite wound on a foreleg (Anon, 1980). Matthews & Sargent (1977) examined 285 British hares for evidence of mycobacterial infection and isolated five strains, four of which were identified as *M. avium* and one as an untypable mycobactin-

dependent strain. Boughton (1969) isolated *M. avium* from two out of eight grey squirrels caught in England.

Tuberculosis caused by *M. bovis* has been described in captive species of mustelidae in Britain; Head (1959) for example found cases of tuberculosis in mink in 15 farms and stated that acid-fast organisms were very numerous in the lesions. Similarly, Symmers, Thomson & Iland (1953) described a case in a laboratory ferret in which there were enormous numbers of acid-fast bacilli in the tissues. Recently, bovine tuberculosis has been seen in small numbers of free-living stoats in New Zealand (Coleman, 1975).

Lovell & White (1941) have described bovine types of tuberculosis in farmed silver foxes, but there is no record in the literature of its presence in free-living foxes. Sterk (1940) and Löliger (1970) found the lesions in farmed foxes to be of the proliferative type containing large numbers of tubercle bacilli.

Roe deer in both Switzerland (Bouvier, 1963; Bishofberger & Nabhdy, 1964) and Germany (Kurtje, 1961) have been found to be infected with bovine tuberculosis and to have reinfected cattle and possibly badgers. Red deer in New Zealand (Stockdale, 1975) have also been found to be infected. Rankin & McDiarmid (1968) examined a large number of British deer for evidence of tuberculosis but were able only to isolate *M. avium* mainly from the ileo-caecal lymph nodes. Matthews, McDiarmid & Collins (1981) found 16% of roe deer, 6·9% of red deer and up to 32% of fallow deer to be infected with *M. avium*.

Following a major outbreak of tuberculosis in cattle on a farm in South Dorset which has been described by Wilesmith *et al.* (1982) a detailed study of the badgers on this farm took place which indicated that they were heavily infected with *Mycobacterium bovis* (Little *et al.*, 1982). As there was an abundance of other wild mammals in the area, it was decided to examine some to determine whether they also were infected with tuberculosis.

MATERIALS AND METHODS

Domestic animals

Farm animals

There were no sheep reared in the area. A small number of breeding sows were kept on the central farm. These animals were housed but the piglets had access to pasture and a pond from which cattle drank. These piglets, therefore, were potentially exposed to badgers and their excretions and secretions. The progeny were slaughtered at a local abattoir and the carcasses were subject to the usual meat inspection examination which included incision of body lymph nodes.

Cats and dogs

A number of semi-wild cats lived around the farm buildings and three from the central farm were made available for examination. The cats were killed with pentobarbitone sodium and subjected to post-mortem examination and a selection of lymph nodes and other tissues examined by both bacteriological and biological methods as described by Little *et al.* (1982).

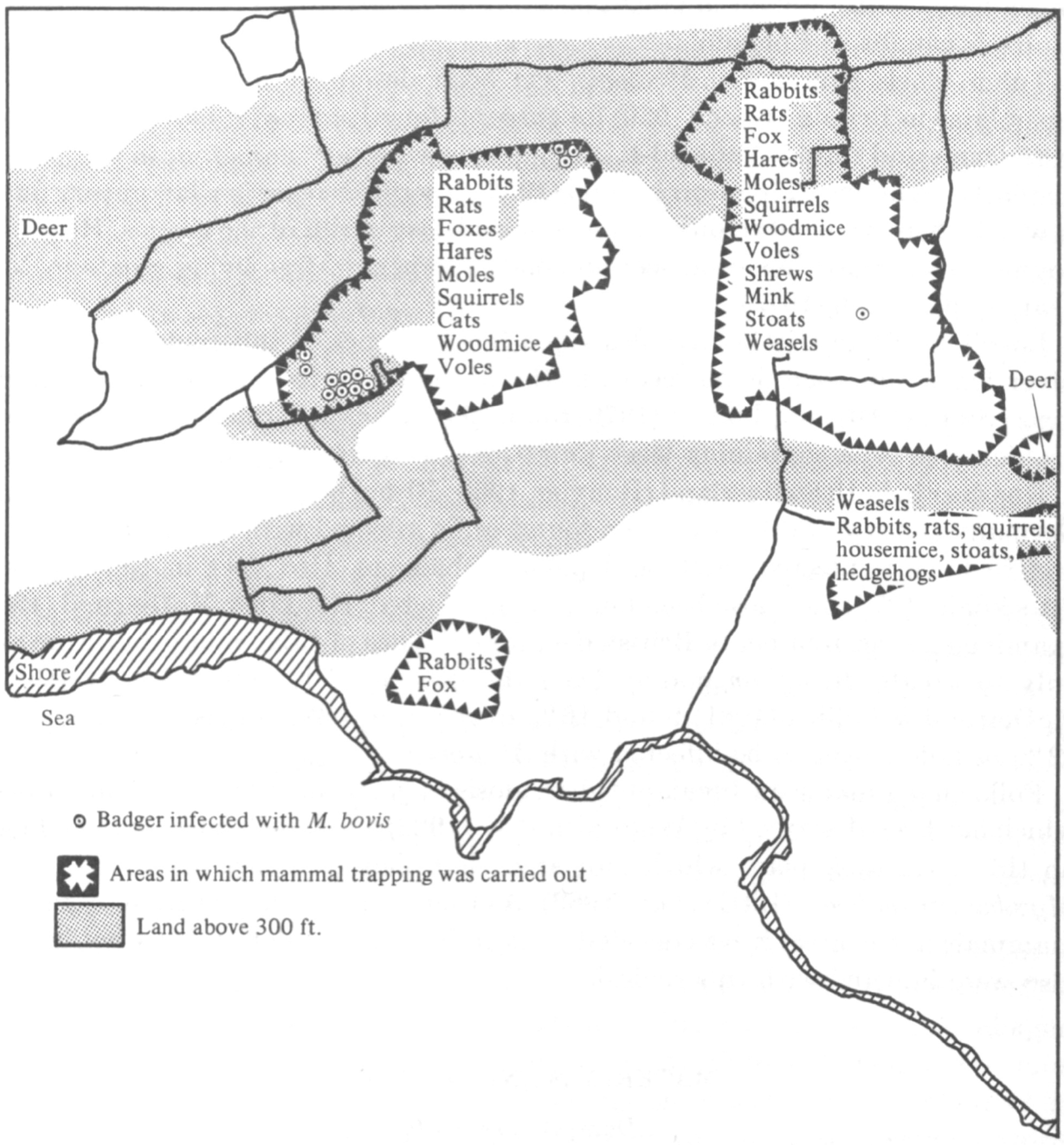

Fig. 1. Location of trapping areas for mammals other than badgers in relation to sites of known infected badgers.

A number of dogs were accidentally live-trapped in badger traps, but all were released and no dogs were examined.

Wild mammals

Before 1976 the badger population was very high and foxes, rabbits, hares, roe deer, stoats and weasels could be found over the entire area. To the west, sika and in small numbers fallow, could also be found. In and around the dairies there were fluctuating numbers of brown rats and housemice. Woodmice, field and bank voles in varying density were established over most of the area.

There were grey squirrels in every piece of woodland and moles were most active on the farmland. Mink were using the river in the eastern end of the central valley;

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Table 1. *Examination of wild life other than badgers for the presence of* Mycobacterium bovis

Species	No. examined	No. from which *M. bovis* was isolated*
Rat (*Rattus norvegicus*)	90	2
Vole (*Mirotus agrestis* and *Clethryonomys glareolus*)	73	—
Rabbit (*Oryctolagus cuniculus*)	57	—
Wood mouse (*Apodemus sylvaticus*)	39	—
Mole (*Talpa europaea*)	33	—
Squirrel (*Sciurus carolinensis*)	27	—
House mouse (*Mus musculus*)	14	—
Weasel (*Mustela nivalis*)	9	—
Stoat (*Mustela erminea*)	7	—
Fox (*Vulpes vulpes*)	7	1
Shrew (*Sorex araneus*)	3	—
Hedgehog (*Erinaceus europaeus*)	3	—
Mink (*Mustela vison*)	2	—
Roe Deer (*Capreolus capreolus*)	6	—
Sika Deer (*Cervus nippon*)	2	—
Fallow Deer (*Dama dama*)	1	—
Hare (*Lepus europaeus*)	7	—

* N.B. None of these mammals showed lesions of tuberculosis.

shrews were found at one location in the central valley. The only hedgehogs found in the area were in the fields near the sea.

A few of the various mammals sent in were road casualties; the deer samples were mainly the results of a cull undertaken by the army and most of the foxes were acquired as a result of the activities of local shepherds and gamekeepers. All the other mammals were either caught in traps or shot, deliberately to sample the fauna, in those areas known to have been used by diseased cattle and badgers.

The cats, rats, squirrels, weasels, hedgehogs and mink were taken in mink cage traps or tunnel traps; the mice, voles and shrews in Longworth traps and the rabbits and hares were shot or snared. The moles were taken in either Duffus or pincer traps set mainly in pasture.

An attempt was made to obtain a representative number of the different species of wild mammal present on the farm.

The areas studied are shown in Fig. 1. The animals were transported by road as quickly as possible to the Central Veterinary Laboratory where they were subject to a detailed post-mortem examination and lesions or pools of normal lymph nodes were examined for the presence of tuberculosis by histological, culture and biological tests as described by Little *et al.* (1982).

RESULTS

Domestic animals

In 1970 a batch of 12 pigs was slaughtered and all 12 were condemned as unfit for human consumption at post-mortem inspection because of multiple lesions which were suspected of being tuberculous. Some of the lesions were submitted to the Central Veterinary Laboratory and *M. bovis* was isolated. The pigs were the progeny of three sows which were subsequently slaughtered but were found at post-mortem examination to be free from tuberculosis. *M. bovis* was not recovered from the water of the pond.

None of the three cats examined had any lesions of tuberculosis and there was no isolation from either tissues or lymph nodes.

Wild mammals

The number of wild mammals caught and their location is shown in Table 1 and on Fig. 1.

None of the mammals had lesions resembling tuberculosis at post-mortem examination, although many showed other lesions and tapeworm cysticerci were common.

M. bovis was isolated from a fox caught at the western end of the central ridge. This fox showed no lesions and the positive culture was seeded with material from a pool of normal lymph nodes.

M. bovis was also isolated from a collection of normal lymph nodes from two rats caught at the central farm.

DISCUSSION

On a large farm such as this one a number of different species of mammal other than cattle which are susceptible to *M. bovis* may exist. The farm was composed of a number of different types of habitat supporting the normal range of mammals present in southern England in addition to other domestic animals reared on the farm. This investigation provided the opportunity not only to investigate the extent of tuberculosis in cattle and badgers but also to explore the possibility of the existence of reservoirs of tuberculosis in other species of domestic or free-living mammals.

Although the total area under study was some 1200 hectares, the trapping of wild animals was restricted to the areas shown in Fig. 1. These areas were chosen because they were associated either with the sets from which tuberculous badgers were found or with areas where the infected cattle had been. Thus, the areas trapped were only a small part of the total area. It is difficult to estimate population sizes of free-living species but a high proportion of rats, rabbits, voles, mice, stoats, weasels, mink and squirrels within the area sampled were caught.

Prior to the discovery of bovine tuberculosis in badgers (Muirhead, Gallagher & Burn, 1974) *M. bovis* had been isolated only on single occasions from free-living hedgehogs (Hamerton, 1935) and rats (Bosworth, 1940) in Great Britain. Thus,

until the emergence of the badger in Britain and the opossum in New Zealand as important hosts, cattle have appeared as the normal reservoir host of *M. bovis* throughout the world. A certain amount of spread occurred to man and other domestic animals which to a large extent have acted as accidental hosts.

More active interest in wildlife reservoirs of infection in recent years has demonstrated the presence of infection with *M. bovis* but not active disease in a very small number of foxes, rats and moles in Britain (Report, 1979). Similarly, in New Zealand a very small number of cases of tuberculosis have been seen in wild species other than opossums such as feral pigs and goats, deer, rats, stoats and hedgehogs (Stockdale, 1975; Coleman, 1975).

In this study, apart from infection in badgers, *M. bovis* was isolated from two rats and a single fox, none of which had visible lesions of tuberculosis, the *M. bovis* being isolated from collections of normal lymph nodes. The rats may possibly have become infected by eating undigested grains of maize which were sometimes observed in badger faeces on this farm or by eating carcasses of dead tuberculous badgers. Neal (1977) states that rats quite frequently use badger sets although the infected rats in this investigation were caught near one of the dairies. The non-progressive nature of the disease in rats, however, makes them unlikely to transmit the infection to other rats or other species of mammal. Excretion is unlikely to occur and the rat may be regarded as a dead-end host.

Foxes are frequent tenants of unused badger sets (Neal, 1977) and appear to prefer to use such sets rather than digging their own earths. Neal describes the fox as having a commensal relationship with badgers. The fox is an opportunist feeder and will take carrion. Thus, foxes could become infected by scavenging on the carcass of a tuberculous badger. Free-living foxes are usually solitary animals whose populations remain dispersed (Lloyd, 1977) and thus their behaviour is not conducive to the establishment of a reservoir of tuberculosis.

None of the moles or hedgehogs caught in this investigation had lesions resembling tuberculosis, nor was *M. bovis* isolated. However, *M. bovis* had been isolated from two moles caught on farms in Cornwall where both badgers and cattle were affected with tuberculosis (Report, 1979) but neither was reported as having lesions. Since moles spend most of their time underground as the sole occupant of a system of tunnels (Mead-Briggs, 1977) the opportunity for spread of infection between moles or from moles to cattle is very limited. Hedgehogs have previously been reported as being infected with *M. bovis* in Britain (Hamerton, 1935) but in recent years the infection has not been found (Matthews & McDiarmid, 1977; Report, 1979). Although hedgehogs are common on pasture and thus have a close association with cattle, they lead solitary lives with temporal if not spatial separation (Morris, 1977). Again, the social behaviour of the species is not conducive to a reservoir of tuberculosis becoming established in this species.

Although various species of mustelidae have been found to be infected with *M. bovis*, in the wild these species are predators and dense populations do not usually develop, they tend to remain separate except for breeding and have their own territories which militates against the spread of tuberculosis in such populations.

Other wild species which are often present in large numbers in close association

with cattle are voles, mice and shrews. None of the small mammals in this investigation or other recent investigations at other locations (Report, 1979) in which some 750 voles and over 400 mice have been examined, have either lesions of tuberculosis been seen or has the vole bacillus *M. microti* been isolated. It would be of interest to re-examine some of the sites where Wells originally found infected voles, to determine whether the disease still exists or has naturally become extinct.

In this investigation a high proportion of the rats, rabbits, voles, mice, stoats, weasels, mink and squirrels living within the area sampled were caught. The population of wide-ranging species such as deer was low in the area and the sample is considered to be sufficiently large and representative. The sampling fractions of these wild mammals populations were in fact much greater than that for the badger population but the absence of lesions indicates these other species are not acting as a source of infection for cattle.

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