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BOVINE TUBERCULOSIS IN CATTLE AND BADGERS

(*Meles meles*) IN GREAT BRITAIN

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A compulsory area eradication programme for tuberculosis in cattle was initiated in 1950, following a voluntary scheme. The programme was successful and in 1960 Great Britain was considered as Attested due to the low incidence of infection (Evans and Thompson 1981). In 1965 0.06% of cattle reacted to the tuberculin test, 1% of cattle herds being infected. *Mycobacterium bovis* has, however, remained a problem in areas of south-west (sw) England. A tuberculous badger was found in this area in 1971 (Muirhead et al 1974) and since then a considerable amount of circumstantial evidence has been accumulated that badgers are a source of *M. bovis* for cattle. This paper describes an analysis of the relationship between the rate of herd infection and badger sett density carried out to examine further this causal association.

MATERIALS AND METHODS

Infected herds disclosed during the 7 year period 1972 to 1978 were used in this analysis. *M. bovis* infection in a herd was defined as either the detection of visible lesions of tuberculosis and/or the isolation of *M. bovis* at slaughter in animals exhibiting a positive reaction to the tuberculin test or the presence of visible lesions of tuberculosis in an animal at routine slaughter. The infected herds were categorised by the origin of infection attributed as a result of investigations to determine whether infection could have been introduced by the purchase of animals, by temporary contact with cattle from other herds of other species including humans. Since 1974, the possibility of infected badgers as a source of infection has been considered in an increasing proportion of herds in the sw region of England where the usual investigations have failed to identify a source of infection. In the remainder of Great Britain investigations to determine the possible role of badgers as a source of infection were not carried out during the time period examined. The areal density of badger setts in England and Wales, as estimated by the collation of data recorded by members of the Mammal Society used in this analysis is shown in Fig.1. It is based on estimates of sett densities in 10 x 10 Km squares.

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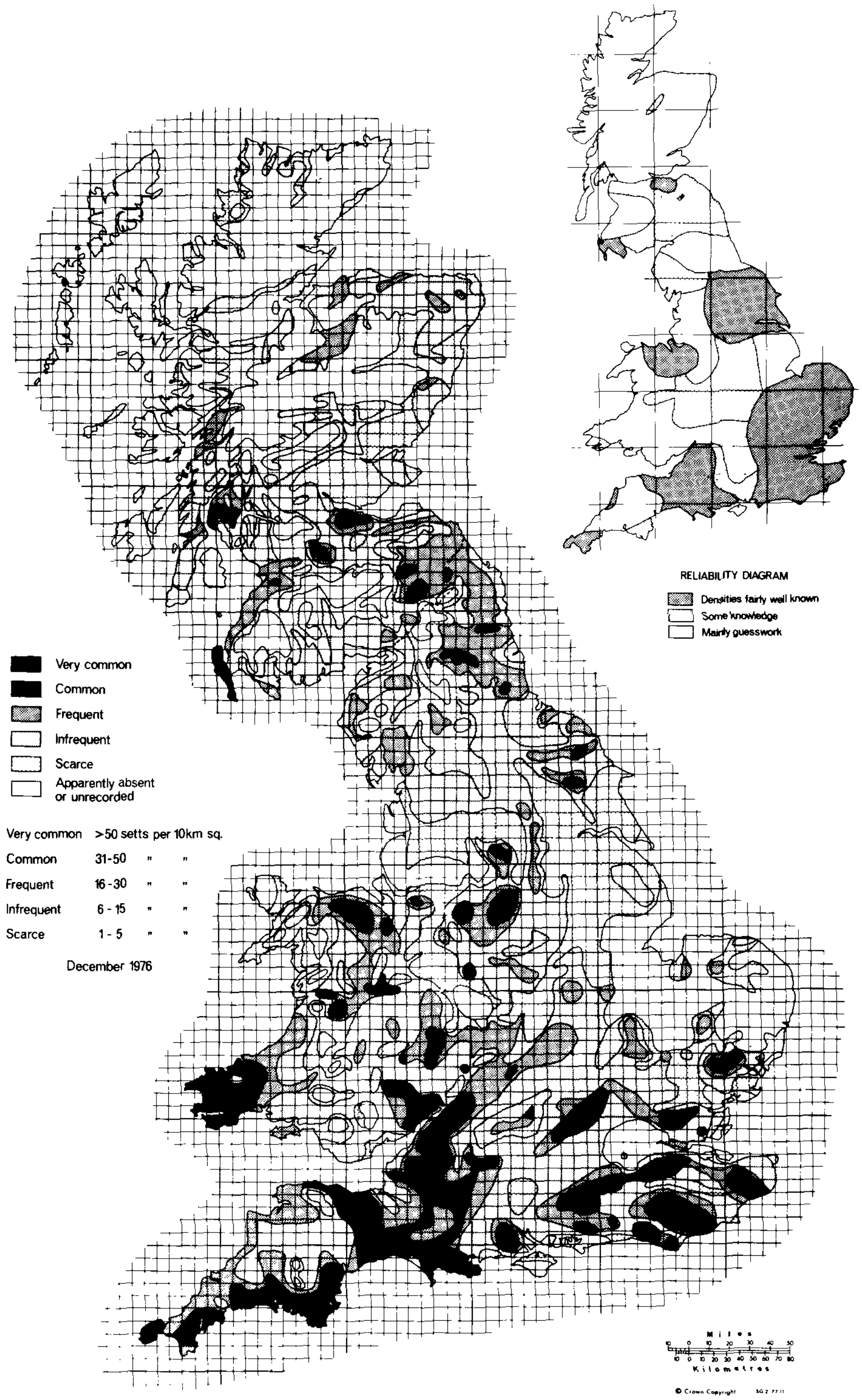


Fig. 1. Distribution of Badger Setts in Great Britain

A herd infection rate was calculated for each of the six badger sett density classes recorded. The number of herds at risk in each badger sett density class was estimated by drawing a systematic random sample of herds from the 1975 annual census and attributing to each herd selected the badger sett density at the centre of the parish in which the herd was situated. Infected herds were similarly attributed the badger sett density at the centre of their parish. A rate of herd infection in each badger sett density was estimated and a conservative 95% confidence interval associated with it was determined as described by Cox and Lewis (1966) using the chart given in Pearson and Hartley (1970) and assuming numerator and denominator to be generated by independent Poisson processes. The number of herds at risk was not raised from the number in the sample to the number in the whole population; these infection rates are therefore referred to as relative herd infection rates. This procedure was carried out separately for the counties of Gloucestershire/Avon, Cornwall and the combined counties in England and Wales outside the sw region, the samples of herds at risk comprising 600, 700 and 500 herds, respectively.

RESULTS

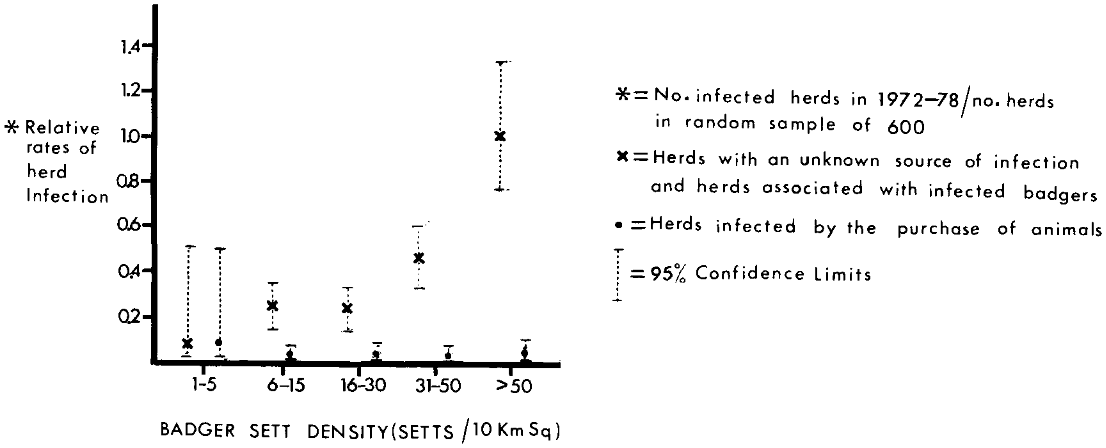
Table 1. Distribution of TB Infected Herds and Random Samples of Cattle Herds in 3 Areas by Badger Sett Density

County	Source of Infection	Badger sett density (setts/10 Km.sq.)					
		0	1-5	6-15	16-30	31-50	50
Gloucester & Avon	Purchased animals	0	1	2	5	4	2
	Badgers	0	0	13	27	72	86
	Unknown	0	1	15	9	13	16
	Random sample	0	14	123	174	188	101
Cornwall	Purchased animals	0	0	2	19	6	10
	Contiguous premises	0	0	2	3	2	11
	Badgers	0	0	1	11	10	31
	Unknown	0	0	17	83	34	98
	Random sample	0	0	79	302	215	104
England and Wales excl. south west region	Known	4	25	60	28	25	
	Unknown	1	17	32	17	27	
	Random sample	39	129	171	100	61	

During the 7 year period 1972-78 842 infected herds were disclosed in England and Wales. 606 of these herds were located in the sw region of England. The distribution of infected herds, by source of infection in Gloucestershire/Avon, Cornwall and counties in Wales and England excluding those in the south-west region and the three random samples of herds in these areas, by badger sett density, are shown in Table 1.

Gloucestershire/Avon

The relative herd infection rates and their 95% confidence limits for herds whose source of infection was attributed to badgers or for which no source was found and for herds whose source of infection was purchased animals, by badger sett density, is shown in Fig.1.



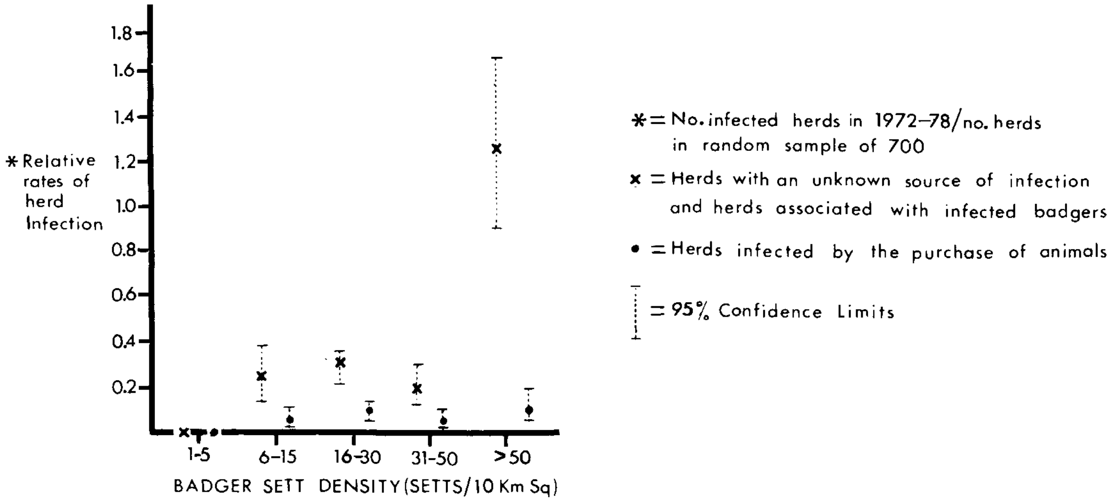
Relative rates of herd infection and 95% confidence limits in Gloucestershire and Avon by badger sett density

Figure 1

The relative infection rates of herds whose source of infection was purchased animals show no association with badger sett density. The relative infection rates of herds with either no established source of infection or with an origin attributed to badgers indicate a positive association between herd infection, attributed to these 2 sources, and badger sett density. The relative herd infection rate for these herds in areas where the badger sett density was recorded as greater than 31-50 setts per 10 Km sq. was higher than in areas of lower sett density. This difference is statistically significant at the 5% level. Similarly the relative herd infection rate in areas where the badger sett density was recorded as greater than 50 setts per 10 Km sq. was higher than in areas with a recorded sett density of 31-50 setts per 10 Km sq. This difference is statistically significant at the 5% level.

Cornwall

The relative infection rates and their 95% confidence limits of herds whose source of infection was attributed to badgers or in which no source was found and of herds whose source of infection was purchased animals, by badger sett density, is shown in Fig.2.



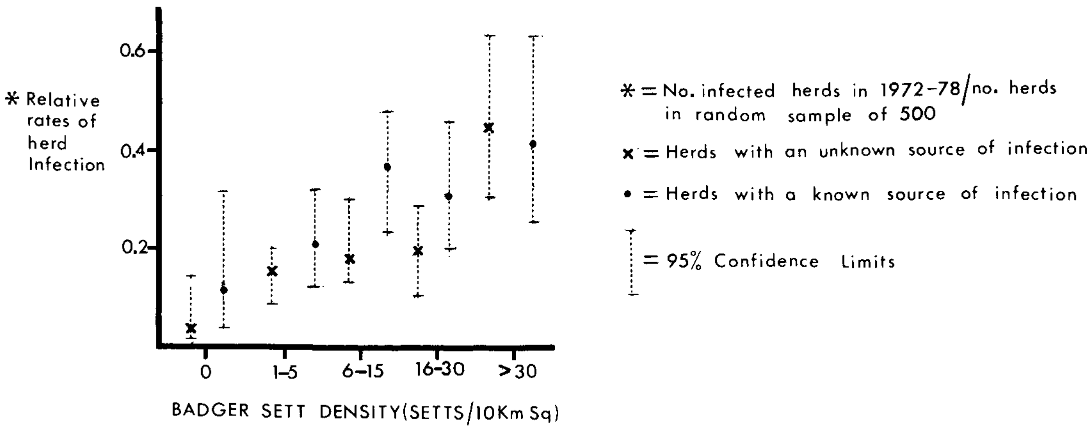
Relative rates of herd infection and 95% confidence limits in Cornwall by badger sett density

Figure 2

The relative rates of infection for herds whose source of infection was purchased animals show no association with badger sett density. The relative infection rates of herds with either no established source of infection or with an origin attributed to badgers indicate a positive association between herd infection, attributed to these 2 sources, and badger sett density. The relative herd infection rate for those herds in areas where the badger sett density was recorded as greater than 50 setts per 10 Km sq. was higher than in areas of lower sett density. This difference is statistically significant at the 5% level.

England and Wales excluding the south-west region

The relative infection rates of herds with a known origin of infection and herds with no known origin of infection, by badger sett density, is shown in Fig.3. The relative infection rates of herds with no attributed source of infection indicates an association between herd infection, with no established source of infection, and badger sett density. The relative herd infection rate for this group of herds where the badger sett density was recorded as greater than 30 setts per 10 Km sq. was higher than in areas of lower badger sett density. This difference is statistically significant at the 5% level. The relative rates of herd infection for herds with an attributed source of infection show an apparent increase with badger sett density, but this is not statistically significant at the 5% level.



Relative rates of herd infection and 95% confidence limits in England and Wales excluding the south west region by badger sett density

Figure 3

DISCUSSION

The statutory protection of the badger in Great Britain has imposed limitations on epidemiological studies to substantiate or refute the apparent causal association between M. bovis infection in badgers and infection in cattle as have the absence of a diagnostic test in the live badger (Little et al, 1982a) and the low rate and sporadic nature of herd infection (Wilesmith 1982). The only method to estimate the prevalence of infection within a badger population is by trapping a sample for post-mortem and bacteriological examination. It has not been possible to sample populations in the absence of herd infection. Therefore a case-control study was not possible and the selections of controls would have posed problems because of the low rate of transmission of infection from badgers to cattle.

There was however a need to examine the causal association using a more formal analytical approach and assess the possible risk of herd infection from badgers outside the sw region. The data of badger sett density used in this analysis provides only a broad categorisation, and consequently exposure of herds to badgers, as they are based on 10 x 10 Km squares. Within such a large area there may be great variation in density (Neal 1977), but this distribution apparently provides a sufficiently valid representation of the relative frequencies of sett density in 10 x 10 Km. squares.

The relationship between herd infection and badger sett density in Cornwall and Gloucestershire/Avon found in this study substantiates the circumstantial evidence accumulated in these and other counties

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in the sw region of England. Badgers were not investigated as a source of infection for cattle outside this region during the time period covered, but M. bovis has now been disclosed in badgers in 7 counties outside the sw region (Report 1979, 1981, 1982). The results of this study support these recent findings that badgers are a potential source of infection throughout the country. The apparent increase in risk of infection from a "known source" for herds in areas of high badger sett density (Fig.6), although not statistically significant, is not inconsistent with a hypothesis that badgers are frequently the ultimate origin of cattle infection. An increased rate of infection from badgers in an area could result in an increase in secondary infections and there will be an increase in the number of neighbouring herds suffering simultaneous infection from badgers some of which could have been attributed to secondary infection i.e. to a "known source".

The geographical distribution of badger setts is likely to be related to the distribution of other mammals such as rabbits and foxes (Neal 1977). Therefore this analysis on its own cannot be said to distinguish the badger from other species in the epidemiology of bovine tuberculosis. However, intensive studies of other mammals have been carried out in 3 areas in sw England. These failed to reveal mammalian species other than the badger, acting as a maintenance host for M. bovis (Barrow and Gallagher 1981, Little et al 1982b). Long term intervention studies in 2 areas, where badger setts have been gassed with cyanide and recolonisation by badgers prevented, resulting in freedom from infection in cattle, have provided additional evidence that badgers were the source of infection and other mammals were not significant in the epidemiology (Report 1979, Wilesmith et al 1982, Little et al 1982c).

It has not yet been established whether the prevalence of infection in badger populations is density dependant, but this is the subject of current research. The validity of the sett density distribution used is subject to geographical variation due to observer bias and there is difficulty in estimating population size from sett density. Also, cattle cannot be regarded as a reliable sentinel of the prevalence of infection in badgers because of the variation in the degree of contact between the two species. Despite these limitations this study may provide an indication of the order of magnitude of the threshold density, in terms of setts.

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