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THE ECOLOGY OF LYME BORRELIOSIS IN THE UK

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INTRODUCTION

Comparatively little is known of the ecology of *Borrelia burgdorferi (*the aetiological agent of Lyme borreliosis) in the UK. Although ecological similarities with continental Europe are apparent, the physical isolation of the UK (as an island), and the different host preferences of *Ixodes ricinus* (the principal European vector of *B. burgdorferi*) suggest likely differences. Indeed, *I. ricinus* is known as the sheep tick in the UK whereas on the Continent it is called the wood tick.

UK *BORRELIA BURGDORFERI*

An essential step in understanding the ecology of Lyme borreliosis is defining the properties of the aetiological agent. This is important for selecting suitable diagnostic reagents and in understanding the infection characteristics that influence transmission dynamics. Isolation of UK *B. burgdorferi* has proved difficult and to date only one isolate obtained by Dr S. Cutler (Charing Cross Hospital, London) is freely available for study.

We succeeded in obtaining only one isolate from 85 tick pools (representing 504 questing *I. ricinus* nymphs and adults) collected in the UK. In contrast, using identical conditions, *B. burgdorferi* was isolated from one of 7 tick pools (87 ticks) from Switzerland, and a single pool of 10 ticks from Slovakia.[1] Examination of 100 questing *I. ricinus* nymphs from a UK Lyme disease focus, using specific immunofluorescence, revealed 8 ticks positive for *B. burgdorferi* spirochaetes. Of these, 6 nymphs contained 1 to 10 spirochaetes and only one nymph had more than 100 spirochaetes. The low numbers of spirochaetes compared with those recorded on the Continent[2] partly explain the poor success rate in isolating UK *B. burgdorferi.* However, even if the one successful isolation was due to the presence of a highly infected tick, we would expect to have obtained a greater number of UK *B. burgdorferi* isolates.

To examine the problem further, the isolation procedures were monitored by the polymerase chain reaction (PCR using a nested set of primers specific for the OspA gene of *B. burgdorferi*[3]). Eleven of 12 tick samples were PCR positive after 2 weeks in culture but only one sample was positive after 4 weeks and motile spirochaetes were not detected by dark field microscopy.[1] The results indicate that UK B. *burgdorferi* did not adapt to the culture conditions. This observation, together with the comparative ease with which Swiss and Slovakian *B. burgdorferi* were isolated using identical conditions, suggest that the growth requirements of UK *B. burgdorferi* differ significantly from those of other *B. burgdorferi* strains. One such requirement could be related to the diversity in fatty acid profiles of *Borrelia*.[4,5]

GEOGRAPHICAL DISTRIBUTION OF INFECTED TICKS

To assess the geographical distribution of *B. burgdorferi* in the UK, a network of tick collectors has been established with the help of Dr B. Staines (ITE, Banchory) and Mr R. Youngson (Red Deer Commission). Infected ticks have been identified by PCR.[3] The results of this study have been circulated in two Lyme Disease Newsletters. Although the distribution map (Fig. 1) is influenced by the activities of the tick collectors, infected ticks are obviously common and widespread. The distribution of PCR positive ticks broadly corresponds with the recorded distribution of *I. ricinus*.[6]

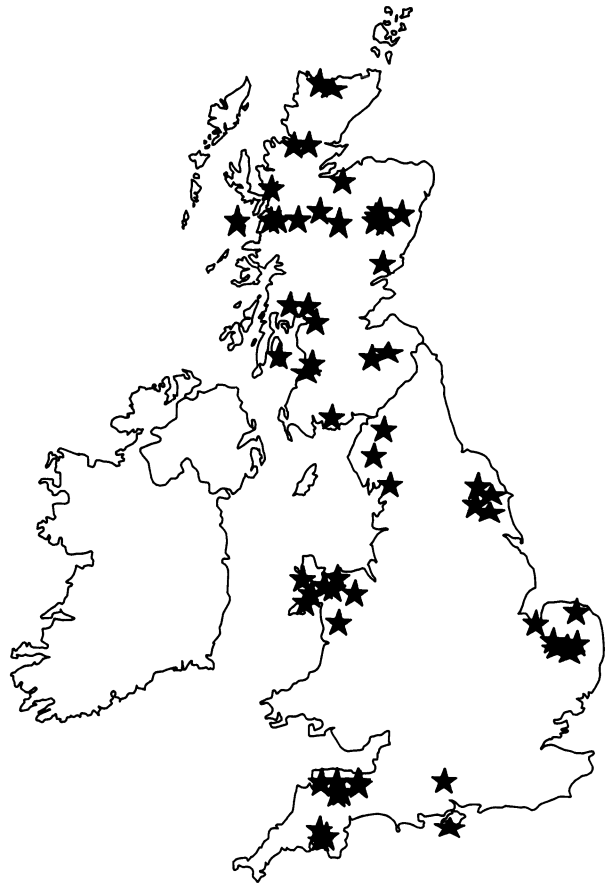

Figure 1. Distribution of *Ixodes ricinus* ticks collected during 1990 to 1992 and identified as PCR positive for *Borrelia burgdorferi.* Collection sites of positive ticks are indicated by a star.

Although *I. ricinus* was by far the most prevalent species collected and diagnosed PCR positive (Fig. 1), other ixodid species found in the UK were identified as positive (Table 1). The full range of potential vector species must be taken into account in studies of the ecology of Lyme borreliosis. For example, *I. hexagonus* has been shown experimentally to be a competent vector of *B. burgdorferi*[7] and in the UK, PCR positive *I. hexagonus* have been found in areas (e.g. Oxfordshire) where *I. ricinus* is not recorded. Thus *I. hexagonus* may extend the range of *B. burgdorferi* beyond that defined by the geographical distribution of *I. ricinus*.

Table 1. Tick species collected in the UK and diagnosed as PCR positive for *Borrelia burgdorferi.*

Tick species	Location	Host associations
Ixodes ricinus	most of UK	numerous vertebrate spp.
Ixodes hexagonus	England	hedgehogs, dogs, cats
Ixodes uriae	Scotland	seabirds
Haemaphysalis punctata	coastal Wales	sheep

Analysis of the PCR results for *I. ricinus* collected in the UK revealed a higher percentage of positives among unfed ticks compared with engorged ticks of the same stage (Fig. 2). This is consistent with reports that constituents of the bloodmeal inhibit the PCR reaction.[8] There was little difference in the proportions of positive unfed adults and nymphs suggesting that most of the infections in the tick population were acquired by feeding larvae and maintained trans-stadially. The detection of two PCR positive pools of questing larvae indicate that transovarial transmission of *B. burgdorferi* occurs from the infected female adult to the succeeding tick generation, as described by other workers.[9] Immunofluorescence assay of unfed *I. ricinus* larvae derived in the laboratory from engorged females collected in a UK focus of Lyme disease revealed that 1.5% larvae were infected.

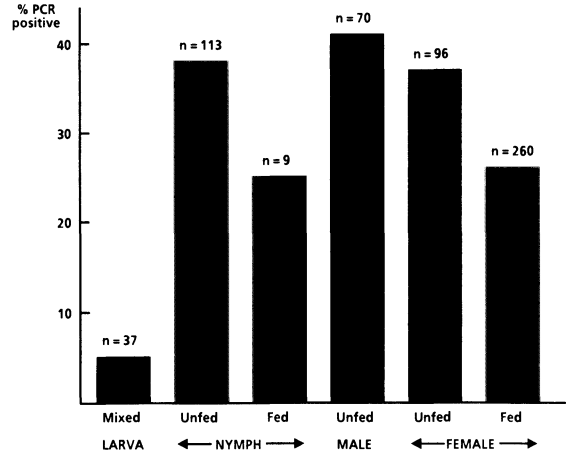

Figure 2. *Ixodes ricinus* ticks collected in Lyme disease foci and identified as PCR positive for *Borrelia burgdorferi.* n=total number examined; mixed=fed and unfed larvae.

VERTEBRATE HOSTS

Most of the feeding *I. ricinus* ticks collected in the UK (Fig. 1) have been from red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) which we assume reflects a collection bias rather than a specific host preference. In addition, PCR positive ticks have been collected from several other wild and domestic vertebrates, *viz.* sheep, cattle, horses, dogs, cats, pheasants (*Phasianus colchicus*), squirrels (*Sciurus carolinensis*), fieldmice (*Apodemus sylvaticus*), and bank voles (*Clethrionomys glareolus*). The susceptibility of these species to infection with UK *B. burgdorferi* is as yet largely undetermined, but even species resistant to infection by *B. burgdorferi* may have profound effects on the prevalence and transmission dynamics of *B. burgdorferi* through their influence on the tick vector population dynamics.

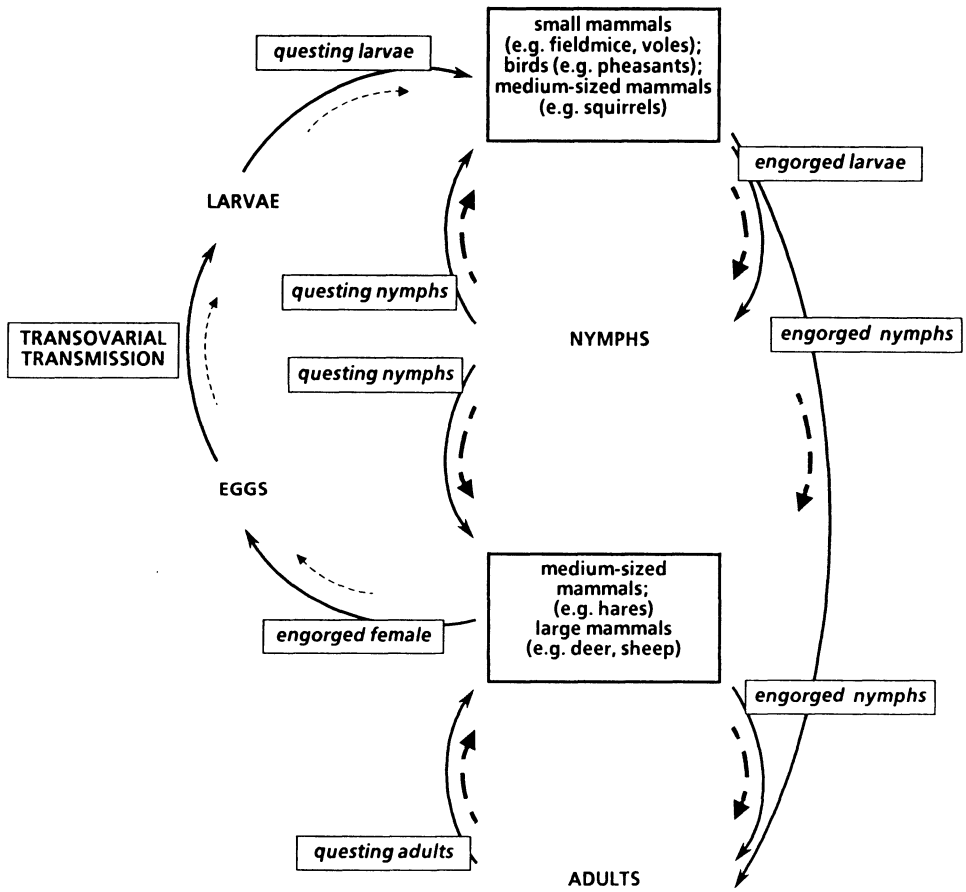

Figure 3. Model of *Borrelia burgdorferi* transmission cycle in the UK.
Solid arrows=life cycle of Ixodes ricinus; broken arrows=direction and intensity of *B. burgdorferi* transmission.

TRANSMISSION CYCLE

The ecology of Lyme borreliosis is defined by the transmission cycle of *B. burgdorferi.* A model is shown in Fig. 3 based on our preliminary results. In depth studies in a woodland ecosystem (Thetford Forest) and a sheep-upland ecosystem (Cumbria) are being undertaken to test key points in the transmission cycle, e.g. the contribution of transovarial transmission to the transmission dynamics. Another important question is the identity of the vertebrate host species that ensures transmission from nymphal to larval populations. This requires that larvae and nymphs feed on the same individual hosts since nymphs are the principal source of infection for vertebrates on which uninfected larvae feed. The larva:nymph ratio for fieldmice trapped in Thetford Forest during 1991-92 was 274:1 which is consistent with observations of other workers.[10] In contrast, the autumn ratio for squirrels was 3:1 and on pheasants, 1:15. The comparative roles of rodents, squirrels and pheasants in maintaining *B. burgdorferi* in woodland habitats in the UK is under investigation, as is the role of sheep in faunistically impoverished areas of northern England.

Acknowledgements

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