Infection of laboratory mice by Murid herpesvirus 4 (MHV-4) is an excellent model system for the study of gammaherpesvirus pathogenesis and for the development of therapeutic strategies against these viruses (Nash et al., 2001; Stewart, 1999). Following intranasal inoculation of mice with MHV-4 strain 68 (MHV-68), an initial productive infection occurs in the lungs (Sunil-Chandra et al., 1992a). This is cleared from the lungs around day 10 p.i. by CD8+ T-cells (Ehtisham et al., 1993) but the virus then persists in a latent form in epithelial cells at this site (Stewart et al., 1998). MHV-68 spreads to the spleen during the subsequent viraemia, where it becomes latent in B lymphocytes, macrophages and dendritic cells (Flano et al., 2000; Sunil-Chandra et al., 1992b; Usherwood et al., 1996; Weck et al., 1999).

In spite of our knowledge of its pathogenesis in laboratory mice, little is known about the epidemiology and diversity of MHV-4 in the wild. Field studies in Slovakia, originally aimed at identifying a vector for flaviviruses, resulted in the isolation of five herpesviruses from two species of murid rodents (Blaskovic et al., 1985). However, it was not clear from these studies what the prevalence was in any given species of murid. Field studies aimed at determining the presence of MHV-4-like viruses in the wild have been carried out in Slovakia and have reported a seroprevalence of between 1 and 12% depending on the region (Kozuch et al., 1993; Mistrikova & Blaskovic, 1985). However, it was not clear from these studies what the prevalence was in any given species of murid. The aim of this study was to assess the prevalence of MHV-4 in the species of free-living murid rodents most likely to be its hosts in the UK.

Sera (5–10 μl per live animal and up to 500 μl from killed animals) were collected from wild populations of wood mice (Apodemus sylvaticus), bank voles and field voles (Microtus agrestis) as part of ongoing studies of the ecology of endemic infections of wild rodents (Begon et al., 1999; Birtles et al., 2001; Telfer et al., 2002). Live voles and wood mice were sampled from the north of England and killed wood mice from Northern Ireland (Begon et al., 1999; Chantrey et al., 2003).
Sera were tested for IgG antibody to MHV-4 in an immunofluorescence assay (IFA) essentially as described for cowpox antibody (Crouch et al., 1995) except using MHV-68-infected Vero cells as antigen.

Antibody reactive with MHV-4 was detected in 36 of 273 (13 %) English and 36 of 149 (24 %) Northern Irish wood mice. In contrast, only 8 of 295 (2.7 %) bank vole sera contained detectable antibody to MHV-4, and no antibody was detected in sera from 135 field voles.

Thus, in spite of a number of strains of MHV-4 reported as being isolated from voles in the original studies (Blaskovic et al., 1980), these serological data strongly suggest that MHV-4 is endemic in wood mice but not voles, at least in the UK.

To confirm and extend the serological data, we performed PCR analysis on infected mouse tissues. MHV-4 DNA can be readily detected by PCR analysis in the spleens and lungs of infected mice for the lifetime of the animal (Stewart et al., 1998). Thus, DNA was extracted from the spleens and lungs of wood mice and bank voles using QIAamp tissue kits (Qiagen). To check the integrity of the DNA for amplification, extracted DNA (1 μg) was first amplified by PCR with primers specific for murine β-actin as described previously (Usherwood et al., 2000). All samples were positive (not shown). Samples were next amplified by nested PCR with primers specific for the gp150 gene exactly as described previously (Usherwood et al., 1996). The sensitivity of the assay was such that one copy of viral DNA could be detected in a background of 1 μg of negative cellular DNA as determined by limiting dilution of cloned target DNA. The results are shown in Fig. 1. No product was seen when negative cellular DNA alone was used, showing that there was no contamination of the PCR reactions. Products of the expected size (368 bp) were amplified from DNA derived from both spleen and lungs of one of five bank voles. In contrast, 13 lungs and 6 spleens from 14 wood mice were positive. One wood mouse had no detectable virus DNA in either spleen or lung tissue.

The PCR data support the serological data and the hypothesis that MHV-4 is endemic in wood mice and only rarely found in voles in the UK. Furthermore, since there are no voles in Northern Ireland, bank voles are not required for the infection of wood mice. Bank voles and wood mice share the same habitats (are sympatric) and share other microorganisms such as cowpox virus and several species of bacteria, suggesting that transmission of agents between the two species is possible. Thus, either bank voles are less susceptible to infection with MHV-4 or this agent transmits less well between species.

This study is limited in its ability to describe the pathogenesis of MHV-4 in wild murids. However, viral DNA was detected more frequently in the lungs of wood mice than in their spleens. This backs up data on experimental infection of laboratory mice that show lungs as a major site of persistence and latency (Stewart et al., 1998). There was a higher prevalence of MHV-4 as determined by PCR rather than serology. Potentially, this could be due to a limited sensitivity of the serological assay. However, published data from experimental infection of mice suggest that the antibody response to MHV-4 is weak (Sangster et al., 2000). Thus, it is equally possible that the antibody response to a natural infection may be either weak or short-lived.

Longitudinal studies in several sympatric rodent populations including wood mice are currently under way in order to determine transmission rates and effects of infection with MHV-4 and other pathogens on population dynamics. This will give valuable information on how a gammaherpesvirus transmits within a population. Future experimental

---

**Fig. 1.** PCR analysis of lungs and spleens from wood mice and bank voles. DNAs extracted from the lungs and spleens of wood mice and bank voles were amplified by a nested PCR assay specific for the MHV-68 gp150 gene. Products were electrophoresed through a 2 % agarose gel and visualized by ethidium bromide staining using a UV transilluminator. Results from wood mice are shown above those for bank voles and labelled accordingly. Results from lungs are shown above those from spleens for clarity. Molecular mass determinations were made relative to a 1 kb ladder (Life Technologies).
infection of captive-bred wood mice and bank voles will give information on the relative susceptibility of the two species to infection and the pathogenesis of MHV-4 in its natural host.

ACKNOWLEDGEMENTS

This work was funded in part by a Nuffield Vacation Scholarship for K. R. B. J. P. S. is the recipient of a Royal Society University Research Fellowship. The authors wish to thank all those involved in collecting rodent samples.

REFERENCES


