Temporal dynamics of Puumala hantavirus infection in cyclic bank vole populations

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Introduction

Reservoir host population dynamics determine the infection dynamics of zoonotic pathogens, and thus the risks they pose to humans. In the boreal zone of Northern Europe, bank vole (*Myodes glareolus*) populations undergo cyclic fluctuations that are reflected to the incidence of Puumala hantavirus (PUUV) infections, i.e. nephropathia epidemica (NE), in humans. In this study, we sought for seasonal and multiannual patterns in PUUV infection dynamics in bank voles.

Materials & Methods

We monitored PUUV infections in a highly PUUV endemic area in Central Finland (Konnevesi) for 7 years: monthly trappings on a 5.8 ha capture-mark-recapture grid, and three cross-sectional trappings per year on 14 smaller grids. For the first time, dynamics of PUUV infection were also studied in detail during winter, when the human NE incidence peaks in the boreal zone.

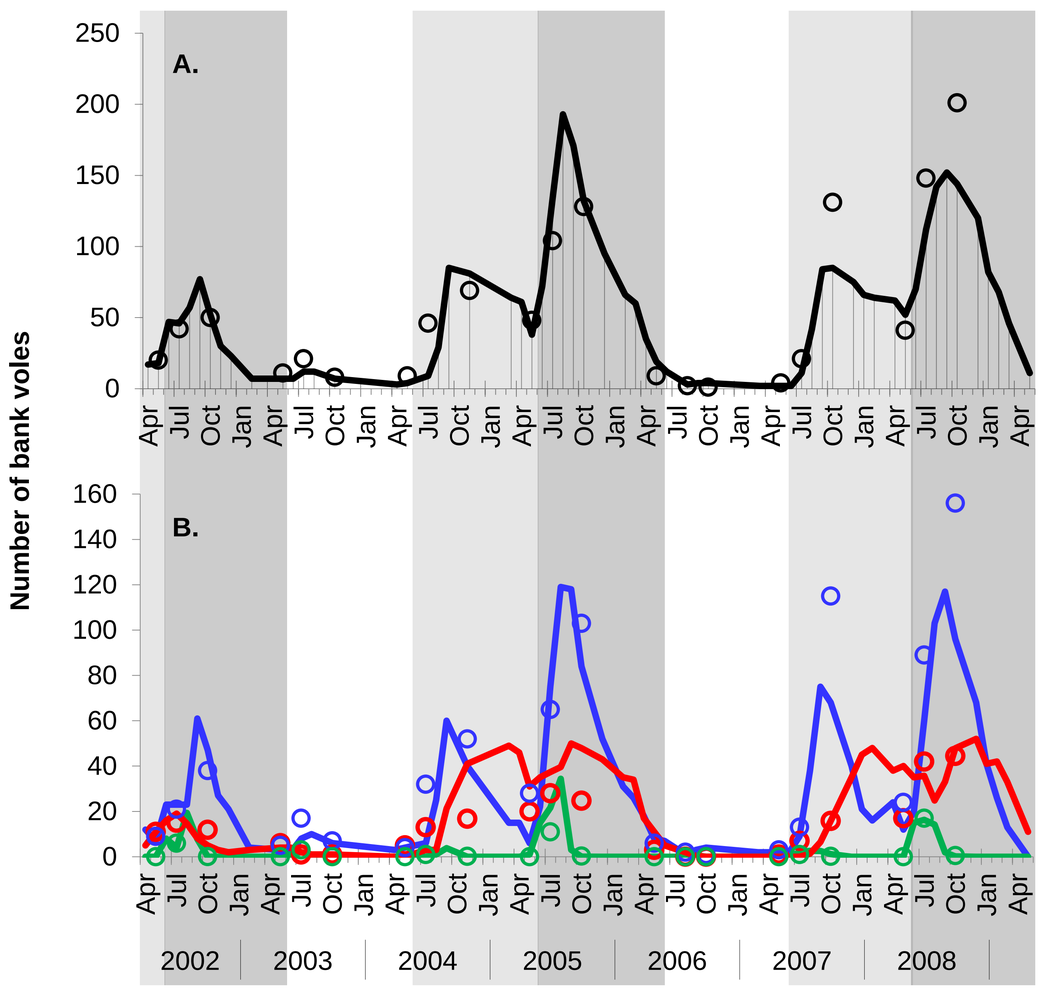

Figure 1. The numbers of bank voles on a 5.8 ha capture-mark-recapture grid (lines) and 14 small cross-sectional study sites (circles), (**A**) in total and (**B**) divided in PUUV infection categories (**Susceptible for PUUV infection**; **infected with PUUV**, and **carrying maternal antibodies**. Shaded areas indicate biological increase (light grey), peak (dark grey) and crash years (white) of the vole density cycle. In (**A**), vertical lines indicate trapping periods on the CMR grid.

Results & Conclusions

Although the total bank vole density peaked already in autumns (Figure 1A), PUUV-infected bank voles were most abundant in the mid-winters of increase and peak years of the 3-year density cycle (Figure 2A).

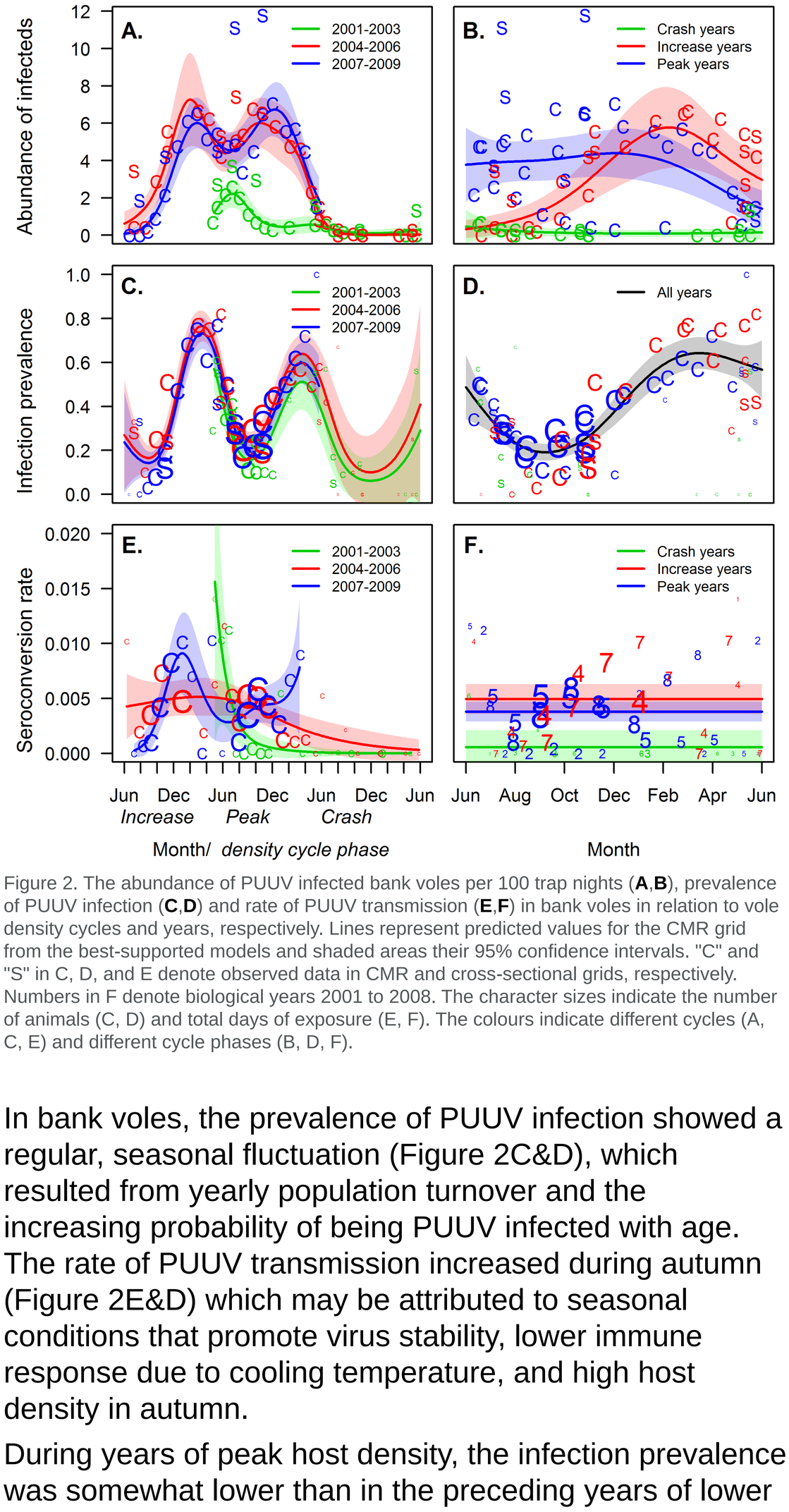

Figure 2. The abundance of PUUV infected bank voles per 100 trap nights (**A**,**B**), prevalence of PUUV infection (**C**,**D**) and rate of PUUV transmission (**E**,**F**) in bank voles in relation to vole density cycles and years, respectively. Lines represent predicted values for the CMR grid from the best-supported models and shaded areas their 95% confidence intervals. "C" and "S" in C, D, and E denote observed data in CMR and cross-sectional grids, respectively. Numbers in F denote biological years 2001 to 2008. The character sizes indicate the number of animals (C, D) and total days of exposure (E, F). The colours indicate different cycles (A, C, E) and different cycle phases (B, D, F).

In bank voles, the prevalence of PUUV infection showed a regular, seasonal fluctuation (Figure 2C&D), which resulted from yearly population turnover and the increasing probability of being PUUV infected with age. The rate of PUUV transmission increased during autumn (Figure 2E&D) which may be attributed to seasonal conditions that promote virus stability, lower immune response due to cooling temperature, and high host density in autumn.

During years of peak host density, the infection prevalence was somewhat lower than in the preceding years of lower density (Figure 2C), which implies that the transmission of PUUV may not be density-dependent. On the other hand, during peak years, young animals were more often protected by maternal antibodies (Figure 1B), which probably constrained the transmission of PUUV.

Our exceptionally intensive long monitoring data provide a solid basis for developing models to predict periods of high human NE risk in the boreal zone of Europe, where NE poses a significant public health threat.

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