Effect of deer density on tick-borne encephalitis dynamics

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Tick-borne infections are caused by pathogens that are transmitted among competent hosts by ticks that become infected following a blood meal. Tick-borne encephalitis (TBE) is an emerging zoonotic disease reported in several European countries, the former Soviet Union and Asia with complex transmission routes that involve various host species. Understanding and quantifying the role of the different hosts involved in the TBE virus cycle is crucial to estimating the threshold conditions for virus emergence and spread (Rosà and Pugliese 2007; Math Biosc 208:216-240). Deer species provide important sources of blood for feeding ticks, but they do not support TBE virus (TBEv) transmission, acting instead as dead-end (i.e. incompetent) hosts. Here, we introduce an eco-epidemiological model to explore the dynamics of tick population and TBE infection. The aim of this work is to provide a robust theoretical framework for empirical observations on the effect of deer host on ticks and TBEv circulation from selected European foci. In agreement with field observations, model results show hump-shaped relationships between deer density and both feeding tick on rodents and the basic reproduction number for TBEv. This suggests that deer may act as tick amplifiers, but may also divert tick bites from competent hosts, thus diluting pathogen transmission. However, our model shows that the mechanism responsible for the dilution effect is more complex than the simple reduction of tick burden on competent hosts. In fact, while the number of feeding ticks on rodents may increase with deer density, the proportion of blood meals on competent compared to incompetent hosts may decrease, triggering infection decline. As a consequence, using the number of ticks per rodent as a TBE risk predictor could be misleading if competent host populations share habitat with incompetent hosts.