Predicting the rate of invasion of the agent of Lyme disease Borrelia burgdorferi

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Identifying invading tick populations provides early warning for emerging tick-borne diseases that are expanding their geographic range. But how fast do tick-borne pathogens invade after ticks become established ? Surveillance data for the tick Ixodes scapularis and the agent of Lyme disease Borrelia burgdorferi in southern Canada, an area where these species currently are invading, revealed a space-time cluster of ticks of low B. burgdorferi infection prevalence in southern Quebec signalling the location where tick populations became established beginning in 2004. The cluster disappeared in 2009 indicating a 5-year gap between tick and B. burgdorferi invasion. Simulations of a model of I. scapularis populations and B. burgdorferi transmission identified numbers of immigrating ticks, rather than host density and diversity, as key determinants of the speed of pathogen invasion after ticks become established. Greater numbers of immigrating infected nymphs would be expected in central compared to eastern Canada because nymphal and larval ticks in source populations in Midwestern USA are active in spring when migratory birds can carry ticks north. Whereas in northeastern USA, tick populations that are sources for immigrating ticks for eastern Canada have active nymphs, but few larvae are active in spring. Consequently, we hypothesised that a 5-year gap would occur between tick and B. burgdorferi invasion in eastern Canada, but a much shorter gap would occur in central Canada. Consistent with this hypothesis, analysis of surveillance data revealed clusters of ticks with low infection prevalence of > 5 years duration in locations in eastern Canada where I. scapularis is invading, but a non-significant cluster of only 3 years duration in regions of central Canada where I. scapularis is invading. We have identified the speed at which the pathogen Borrelia burgdorferi invades following the invasion of the tick Ixodes scapularis, and that the synchrony of larval and nymphal tick activity in spring is a key factor determining the gap between tick and pathogen invasion. This has immediate application in interpreting imminence of Lyme disease risk when surveillance identifies emerging tick populations in Canada. It also has general application in predicting of the speed of invasion of emerging tick-borne pathogens elsewhere in the world.

Joint work with L.R. Lindsay.

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