Climate Warming and Tick-borne Encephalitis, Slovakia

Martin Lukan, Eva Bullova, and Branislav Petko

Increased tick-borne encephalitis (TBE) cases have been reported in central Europe. To investigate temporal trends in the altitude at which TBE cases occur in Slovakia, we analyzed the number of TBE cases during 1961–2004. Since 1980, TBE cases moved from lowlands to submountainous areas, most likely because of rising temperature.

The recent increase in incidence of tick-borne encephalitis (TBE) in central and eastern Europe, especially since 1990, has been attributed to climate warming (1–5) or various socioeconomic factors (6,7). Climate warming in Europe during the past decades has been shown to influence the distribution of *Ixodes ricinus* ticks, the main TBE vector, in several European countries (4,5,8). In central Europe, a sharp increase of TBE has been reported (9,10). Zeman and Beneš showed that global warming affected the geographic and temporal distribution of TBE cases in the Czech Republic (2). Similar development of TBE vertical distribution could be expected in neighboring Slovakia. To investigate temporal trends in the altitude at which TBE cases occur (altitude for TBE) in Slovakia and TBE response to climate warming, we analyzed the total number of TBE cases recorded for persons in Slovakia during 1961–2004.

The Study

Since the 1952 outbreak of TBE in Rožňava, Slovakia, all registered cases of TBE have been required to be reported to the National Health Institute. We analyzed 1,786 TBE cases registered in Slovakia by the Regional Institute of Health during 1961–2004.

Table 1. Nonparametric test and test of stationarity for mean altitude and mean annual air temperature with regard to TBE, Slovakia, 1980–2004

<table>
<thead>
<tr>
<th>Test values</th>
<th>Mean annual air temperature</th>
<th>Mean TBE altitude</th>
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</thead>
<tbody>
<tr>
<td>Data</td>
<td>R̂</td>
<td>p value†</td>
</tr>
<tr>
<td>Mean annual air temp</td>
<td>0.55</td>
<td>0.01</td>
</tr>
<tr>
<td>Mean TBE altitude</td>
<td>0.87</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*†Probability of adopting the null hypothesis of randomness (Spearman R̂) and stationarity (KPSS).

DISPATCHES
The mean altitude for TBE in this period was significantly correlated with mean annual air temperature (Table 2). No significant correlation between the mean altitude for TBE and precipitation could be found. The closest correlation was detected between the mean altitude for TBE and mean annual air temperature of the 3 preceding years. This correlation indicates that the mean altitude for TBE positively responds to climate warming, with a lag of several years. A similar phenomenon was described by Zeman and Beneš (2). At the beginning of the observed period of change, 1980–1984, 48.6% of TBE foci were found at <200 m (Figure 2), 21.6% were found at >300 m, and the highest with repeated reports of TBE was 550 m. During 2000–2004 only 23.0% of locations with repeated reports of TBE were found at <200 m, 27.8% of all locations were found at >400 m, and 5.6% of all TBE foci were found at >600 m (Figure 2). During this period, the highest location with TBE occurrence repeated for several years was 832 m.


In contrast, the total number of TBE foci at >400 m was only 2 during 1980–1984 and increased to 35 during 2000–2004. The altitudinal distribution of TBE foci during 1980–1984 differed significantly from that during 2000–2004 (log-likelihood ratio 31.302, df = 7, p<0.001). The number of lowland TBE foci became significantly lower than in the beginning, a finding that corresponds with the predictions of Randolph and Rogers about the gradual disappearance of TBE from the lowlands of central Europe (7). The dramatic rise in the number of TBE foci at >400 m between 1980–1984 (2 foci) and 2000–2004 (35 foci) is too great to be explained by only socioeconomic factors, such as particular changes in land use, which could increase the range of habitats suitable for tick survival at higher altitudes.

Conclusions

If the observed trend continues, the number of TBE foci in the mountain areas >500 m will probably increase in future decades. Whether this would affect the total number of TBE cases is a matter for discussion. Higher areas are less densely inhabited by local residents but often visited for leisure activities and recreation. The possibility of TBE emergence should be therefore considered by the management of recreation facilities and tourist resorts in areas with habitats suitable for TBE vectors.

Acknowledgments

We dedicate this work to Milan Labuda, who devoted a great part of his life to the study of TBE in Slovakia and unfortunately passed away before this work was finished. We also thank the

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**Table 2. Relationship between mean annual air temperature and mean altitude of tick-borne encephalitis cases, Slovakia, 1980–2004**

<table>
<thead>
<tr>
<th>Temperature lag, y</th>
<th>Correlation coefficient</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (1–3)</td>
<td>0.689†</td>
<td>0.000</td>
</tr>
<tr>
<td>0</td>
<td>0.30‡</td>
<td>0.032</td>
</tr>
<tr>
<td>−1</td>
<td>0.466‡</td>
<td>0.019</td>
</tr>
<tr>
<td>−2</td>
<td>0.433‡</td>
<td>0.031</td>
</tr>
<tr>
<td>−3</td>
<td>0.438‡</td>
<td>0.028</td>
</tr>
</tbody>
</table>

†Correlation is significant at p<0.01 (2-tailed).
‡Correlation is significant at p<0.05 (2-tailed).

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**Figure 2. Comparison between altitudinal distribution of tick-borne encephalitis (TBE) foci during 2 time periods, 1980–1984 (gray bars) and 2000–2004 (white bars), Slovakia. asl, above sea level.**
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Dr Lukan is a researcher at the Institute of High Mountain Biology. As a part of his PhD program, he is studying the distribution of I. ricinus ticks and tick-borne diseases in Slovakia in response to climate change.

References


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