Prediction of possible distribution of tularemia in the Czech Republic

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ABSTRACT: A prediction map of tularemia was constructed on the basis of factors identified as contributing to the existence of current natural foci of tularemia in the Czech Republic. The geographic distribution of a total of 6 different factors was evaluated with respect to their suitability for harbouring natural foci of tularemia. These factors included habitats of alluvial forests, geographic areas of up to 200 m above the sea level, 8.1–10.0°C of mean annual air temperature, 450–700 mm of mean annual precipitation, 1 801–2 000 and 2 001–2 200 h of mean annual sunshine duration and the highest population densities of the European brown hare (*Lepus europaeus*). The whole territory of the Czech Republic was divided into 1 814 unit areas of 5.1 × 8.5 km characterised by the presence or absence of the specific conditions stated above. Analytical tools of the KORMAP GIS program and its capability of combining spatial data to construct a new map were used. There are two main territories of conditions favourable for tularemia in the Czech Republic, i.e., Southern Moravia and Central Bohemia. Areas of 0, 1, 2, 3, 4, 5 and 6 factors favourable for tularemia cover 18 120.30, 27 960.75, 15 259.20, 7 933.05, 5 245.35, 3 337.95 and 780.30 km^2, respectively, of the total area of 78 636.9 km^2 of the Czech Republic. The prediction modelling of possible occurrence of a zoonosis seems to be an economical way of selecting areas of study and research.

Keywords: *Francisella tularensis*; Southern Moravia; Central Bohemia; predictive map

Tularemia, a zoonosis of Northern Hemisphere (Quinn *et al*., 1994), has been known in the Czech Republic since autumn 1936 (Cerny, 2001). Pikula *et al*. (2003) proved that during the years 1971–2000 tularemia had persisted in specific areas of natural foci, but had not been stationary. The evaluation of two 15-year periods resulted in finding a close correlation between the geographic distribution and numbers of natural foci of tularemia in the Czech Republic in 1971 to 1985 and 1986 to 2000. The general environmental conditions of specific areas of natural foci, where tularemia is most prevalent, are as follows: habitats of alluvial forests, geographic areas of up to 200 m above the sea level, 8.1–10.0°C of mean annual air temperature, 450–700 mm of mean annual precipitation and 1 801–2 000 and 2 001–2 200 h of mean annual sunshine duration (Pikula *et al*., 2003). Pikula (1996) also found that there is a correlation between the European brown hare (*Lepus europaeus*) population density and the numbers of natural foci of tularemia. The higher the European brown hare population density, the higher the prevalence of natural foci of tularemia.

Since some activation and spread of natural foci of tularemia could be observed in the Czech Republic and Southern Moravia, in particular in the last decade, it is the aim of this study to use the identified conditions of current occurrence of tularemia for predictive modelling to construct a map of the whole possible distribution of tularemia in the Czech Republic.

MATERIAL AND METHODS

The following computer databases on spatial distribution of conditions favourable for the existence

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of natural foci of tularemia in the Czech Republic were used:

1. Distribution of alluvial areas in the Czech Republic.
2. Distribution of areas of up to 200 m above the sea level in the Czech Republic.
3. Distribution of areas characterised by the mean annual air temperature of 8.1–10.0°C in the Czech Republic.
4. Distribution of areas characterised by the mean annual precipitation of 450–700 mm in the Czech Republic.
5. Distribution of areas characterised by the mean annual sunshine duration of 1 801–2 000 and 2 001–2 200 h in the Czech Republic.
6. Distribution of areas most suitable for the European brown hare (*Lepus europaeus*) population characterised by its highest population densities in the Czech Republic.

The above-mentioned databases representing 50-year mean values of environmental factors have already been described (Pikula and Beklová, 1987; Pikula, 1996; Pikula *et al*., 2003).

For purposes of this study the whole territory of the Czech Republic was divided into 1 814 unit areas of 5.1 × 8.5 km characterised by the presence or absence of the specific conditions stated above. Analytical tools of the KORMAP GIS program (Pikula and Beklová, 1987; Pikula *et al*., 2003) and its capability of combining spatial data to construct a new map were used. In other words, KORMAP determined how many of the six factors favourable for the presence of natural foci of tularemia are present in each unit area. The new map thus depicts 0, 1, 2, 3, 4, 5 and 6 respective areas according to the number of factors favourable for tularemia. These seven areas have then been quantified using the KORMAP program.

RESULTS

Figure 1 shows the Czech Republic with all possible areas of tularemia distribution constructed on the basis of 6 suitable factors. It is obvious that there are essentially two main territories of conditions favourable for tularemia, i.e., Southern Moravia and Central Bohemia. Areas of 0, 1, 2, 3, 4, 5 and 6 factors favourable for tularemia cover 18 120.30, 27 960.75, 15 259.20, 7 933.05, 5 245.35, 3 337.95 and 780.30 km^2, respectively, of the total area of 78 636.9 km^2 of the Czech Republic.

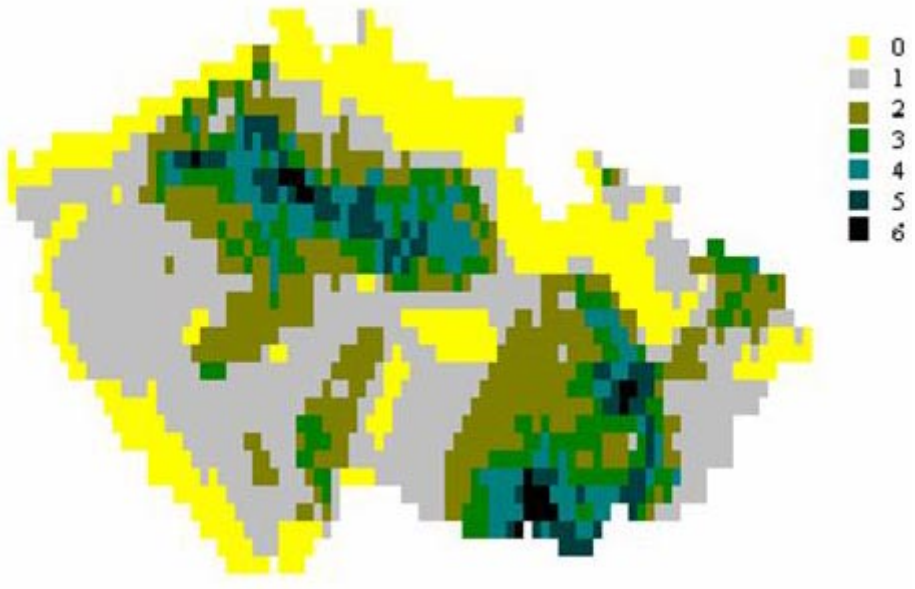

Figure 1. Predictive map of the Czech Republic showing areas of the whole possible distribution of tularemia. Different colours are for the areas of 0–6 factors favourable for tularemia present. The darker the colour, the higher the number of factors favourable for the occurrence of tularemia (i.e., habitats of alluvial forests, geographic areas of up to 200 m above the sea level, 8.1–10.0°C of mean annual air temperature, 450–700 mm of mean annual precipitation, 1 801–2 000 and 2 001–2 200 h of mean annual sunshine duration, and the highest population density of the European brown hare)

DISCUSSION

The predictive map of all possible areas favourable for tularemia has been constructed on the basis of employing 6 ecological factors. Even though there have been attempts to predict the risk of tick-borne diseases (Randolph, 2002), to our knowledge, no one has ever tried to make a prediction model of occurrence of tularemia for a comparison with our results to be made. There are, no doubt, other factors (e.g., distribution of other host mammals, vectors of the disease, etc.) which could be used in such a predictive model. We can speculate that the more factors are used, the more precise the prediction. It would, however, be more elegant to determine the key-role playing factor or factors from a list of many factors of possible influence on tularemia and use this/these one/ones for the prediction. It is clear that further study of these issues is necessary.

In accordance with basic concepts of landscape epidemiology (Pavlovsky, 1964), natural foci of zoonoses such as tularemia persist for a long period of time in distinct geographic areas. We can make a hypothesis that the higher the number of factors favourable for tularemia in the given area, the higher the probability of this zoonosis to become established in natural foci and persistent when it gets to such a new area.

Another point to be discussed is the fact that we have been witnessing climate change which could cause a change in the geographic distribution of factors favourable for the occurrence of zoonoses and make a contribution to their spreading (Epstein, 2001; Kovats *et al*., 2001; Hunter, 2003). The temporal changes of environmental factors, however, have not been incorporated in our simple predictive model of occurrence of tularemia because we have not been trying to evaluate the spatio-temporal aspects of the disease and due to the lack of such data. In this respect the importance of finding the key-role playing factor becomes evident, because it would be technically more feasible to monitor changes of one or only a few factors.

It is also probable that natural foci of tularemia are only sporadic in areas of lower numbers of favourable factors present and most prevalent in areas meeting all conditions necessary. From the prediction map it is clear that there are two main territories of conditions favourable for tularemia in the Czech Republic, i.e., Southern Moravia and Central Bohemia. While the Southern Moravia is a well-known nosoarea for tularemia, in the Central Bohemia it has not yet become so important. This fact can be explained by either this territory being disease-free or harbouring only sporadic natural foci of tularemia or tularemia staying there inactive. Be it so or the other way, on the basis of the prediction model of favourable conditions for tularemia and their distribution in the Czech Republic we can conclude that it is necessary to protect the territory of Central Bohemia from any transfers of animals possibly harbouring *Francisella tularensis.* Looking at the area of Southern and Central Moravia in the prediction map, we can find it clear why natural foci of tularemia could recently be found in more northerly regions. In our opinion, it is due to the existence of conditions favourable for tularemia in these northerly regions.

Lastly, prediction modelling of possible occurrence of a zoonosis is an economical way of selecting areas of active surveillance and directing research activities.

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