

Spatio-temporal aspects of tularemia in Southern Moravia, Czech Republic

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ABSTRACT: In the last decade, apart from the rise of numbers of positive hares and infected humans, we have been witnessing some spread of natural foci of tularemia into more northern areas of Southern Moravia, Czech Republic. It was, therefore, the aim of this paper to evaluate the spatio-temporal development of tularemia in Southern Moravia (in a selected study area of 130 × 90 km) using a geographic information system. Correlation analysis resulted in finding that the geographic distribution of natural foci of tularemia in any year correlated with the distribution in any other year of the study period of 1994–2001. The coefficients of correlation of all possible combinations of distribution in years 1994–2001 vary from 0.38 to 0.96 ($n = 3\,700$, $P = 0.01$). The closer the years, the greater the correlation of distribution of tularemia. It can be stated that, in the study area during the period of eight years, tularemia persisted rather in the same locations but, as the coefficients of correlation do not equal 1.0, some variation in the distribution could be observed.

Keywords: *Francisella tularensis*; natural foci; geographic distribution; geographic information system

Tularemia is a zoonosis occurring in natural foci throughout the Northern Hemisphere with the milder biotype B prevailing in Eurasia (Quinn *et al.*, 1994). In Southern Moravia it has been known since autumn 1936 when 290 humans contracted the external ulceroglandular form of the disease due to handling tularemic hares. During the 1960s, severe epidemics of the professionally-acquired pulmonary form of tularemia in workers in “cold divisions” of sugar factories occurred. There was a 25-year period of low occurrence of this disease in humans interrupted by another epidemic in 1978. In autumn 1994, the number of tularemia cases rose again and, during the season of 1998–1999, 115 human cases of tularemia contracted mainly by handling tularemic hares were reported (Cerný, 2001). These increased numbers of human cases of tularemia coincide with the rise of seroprevalence of hares positive for tularemia from the common value of about 1% to 5.75% in 1994 (Tremel *et al.*, 2002). In the last decade, apart from the rise of numbers of positive hares, we have been witness-

ing some spread of natural foci of tularemia into more northern areas of Southern Moravia.

It was, therefore, our aim to evaluate this spread of tularemia and its spatio-temporal development in Southern Moravia using a geographic information system.

MATERIAL AND METHODS

Aspects of geographic distribution of natural foci of tularemia in Southern Moravia (Czech Republic) were evaluated using source data of monthly reports on infectious diseases in animals by the State Veterinary Administration of the Czech Republic. We selected a study area of 130 × 90 km encompassing districts that harbour most natural foci of tularemia in the Czech Republic (Znojmo, Břeclav, Hodonín) as well as parts of districts where tularemia has occurred recently or its natural foci have not been so numerous (Třebíč, Brno-venkov, Brno-město, Uherské Hradiště, Vyškov, Kroměříž,

Blansko, Žďár nad Sázavou, Prostějov, Přerov). The time perspective included years 1994–2001. In these years there were 128, 161, 164, 171, 173, 185, 197 and 180 natural foci of tularemia, respectively, in the study area. Using the above source data, databases on spatial distribution of natural foci of tularemia in the study area in individual years were created. Geographic computer databases on tularemia in individual years were stored and processed by the KORMAP GIS program (Pikula and Beklova, 1987; Pikula *et al.*, 2002, 2003). The study area was divided into 3 700 unit areas of approximately 3 162 km² which were classified either as being free of tularemia or as harbouring natural foci of tularemia in the given year. The analytical tools of the KORMAP GIS program were employed to evaluate the spatial distribution of natural foci in individual years. All possible combinations of databases of years 1994–2001 were evaluated. One can imagine the evaluation as employing a multi-dimensional (layered) map (database) in order to find out whether tularemia is present or absent in each unit area. Individual layers represent individual years. Comparing two databases (layers representing separate years) we get a frequency table from which it is possible to evaluate the correlation of spatial distribution of tularemia in the study area during the two years.

RESULTS

Table 1 presents results of correlation analysis of the geographic distribution of natural foci of

tularemia in the study area of Southern Moravia in years 1994–2001. Geographic distribution of natural foci of tularemia in any year correlated with the distribution in any other year of the study period. The coefficients of correlation of all possible combinations of distribution in years 1994–2001 vary from 0.38 to 0.96 ($n = 3\,700$, $P = 0.01$). It is clear that the closer the years, the greater the correlation. It can be stated that, in the study area during the period of eight years, tularemia persisted rather in the same locations but, as the coefficients of correlation do not equal 1.0, some variation in the occurrence could be observed.

Despite persistence of tularemia in more or less the same geographic areas in the Southern Moravia, disappearance and new findings of natural foci could be noticed during the study period of 1994 to 2001. Distribution of tularemia has been moving into more northern parts of Southern Moravia.

DISCUSSION

One of the basic concepts of landscape epidemiology mentions the long-term persistence of the disease in distinct geographic areas (Pavlovsky, 1964). Pikula *et al.* (2003) evaluated the long-term persistence of natural foci of tularemia over the whole territory of the Czech Republic. It was found that there is a close correlation between the geographic distribution and numbers of natural foci of tularemia in the Czech Republic in the period of 1971 to 1985 and 1986 to 2000 ($r = 0.91$, $n = 1814$, $t = 92.50$, $P = 0.01$). It means that the natural foci

Table 1. Results of correlation analysis of the geographic distribution of natural foci of tularemia in Southern Moravia in individual years of 1994 to 2001

Year	1994		1995		1996		1997		1998		1999		2000	
	<i>r</i>	<i>t</i>	<i>r</i>	<i>t</i>	<i>r</i>	<i>t</i>	<i>r</i>	<i>t</i>	<i>r</i>	<i>t</i>	<i>r</i>	<i>t</i>	<i>r</i>	<i>t</i>
1995	0.53	38.11												
1996	0.51	36.44	0.95	202.49										
1997	0.49	34.91	0.92	149.63	0.96	234.45								
1998	0.43	29.33	0.80	82.50	0.84	96.95	0.88	113.24						
1999	0.42	28.23	0.79	79.15	0.83	90.82	0.85	101.27	0.93	162.81				
2000	0.39	26.28	0.75	70.98	0.79	79.27	0.82	88.12	0.88	117.32	0.94	173.61		
2001	0.38	25.53	0.71	62.68	0.73	66.83	0.76	71.56	0.74	68.09	0.79	79.36	0.82	90.09

r = coefficient of correlation; *t* = *t*-test; $n = 3\,700$; $P = 0.01$

of tularemia have been persistent over the period of 30 years, but not stationary, and the geographic area of tularemia natural foci occurrence has not grown or diminished considerably in the Czech Republic. There were, however, some changes in the geographic distribution of tularemia. For purposes of the above study, two 15-year periods and means of geographic distribution of tularemia were employed. Results of the current paper can thus be considered as more accurate because of employing a smaller geographic area (study area of 130×90 km), a shorter period of time (eight years) and databases on tularemia distribution in individual years without distorting the reality by computing the mean geographic distribution for some period. The results concerning the study area of Southern Moravia are, however, comparable to those ones found for the whole territory of the Czech Republic and the 30-year period of 1971–2000 even though the coefficients of correlation of all possible combinations of distribution in years 1994–2001 vary from 0.38 to 0.96.

The scale of maps is another point of view that has to be considered when using GIS data processing. For the purpose of evaluation of the whole territory of the Czech Republic Pikula *et al.* (2002, 2003) used data scaled down to unit areas of $24\,384\text{ km}^2$ and as such presented some generalisation of the prevailing value of the phenomenon studied. The current study of tularemia in Southern Moravia in the period of 1994–2001 employed a more precise scale of unit areas of $3\,162\text{ km}^2$.

Geographic distribution of natural foci of tularemia in any year correlated with the distribution in any other year of the study period. The coefficients of correlation of all possible combinations of distribution in years 1994–2001 vary from 0.38 to 0.96, but it is clear that the closer the years, the greater the correlation. The fact that correlation of tularemia distribution is greater in neighbouring years than elsewhere can be explained by the rate of persistence of natural foci as opposed to their disappearance and the way the State Veterinary Administration of the Czech Republic treats natural foci of tularemia. After finding infected animal(s) the State Veterinary Administration of the Czech Republic considers the natural focus to be active for two years even though no other infected animals are found. Due to this administrative approach, persistence (correlation of distribution) of natural foci of tularemia within any two neighbouring years must be the highest.

Despite persistence of tularemia in more-or-less the same geographic areas in the Southern Moravia, disappearance and new findings of natural foci can be noticed during the study period of 1994–2001 (there were 128, 161, 164, 171, 173, 185, 197 and 180 natural foci of tularemia, respectively, in the study area). Distribution of tularemia has been moving into more northern parts of Southern Moravia. As some new natural foci of tularemia were quite far from the previously known ones, it cannot be explained by migrations of reservoir animals represented by small rodents and European brown hare (*Lepus europaeus*). Small rodents such as common vole (*Microtus arvalis*) are not capable of such long distance migrations (Zapletal *et al.*, 2001) and European brown hare is a species maintaining the so-called home range of about 30–100 ha (Broekhuizen and Maaskamp, 1982; Reitz and Leoanrd, 1994; Kunst *et al.*, 2001). Tularemia is either present in the given area or the territory is tularemia-free. In the latter case tularemia can be brought to such a disease-free territory either by transfer of animals when re-populating the area or by the migrating reservoir host – the wild boar (*Sus scrofa*). As far as the wild boar is concerned, Hubalek *et al.* (2002) found up to 17% of seroprevalence for tularemia and the home range of this species is much larger (about 35 km^2 ; Saunders and Kay, 1996) than in other reservoir hosts of tularemia. The wild boar is a species preferring riverine woodlands (Choquenot and Ruscoe, 2003) and as natural foci of tularemia are most frequent in alluvial areas (Pikula *et al.*, 2003), the wild boar could be the species responsible for the spread of tularemia to new areas. As there have not been any transfers of wild animals which would help to explain the spread of tularemia in the study area, there still remains a rational explanation that in these areas natural foci of tularemia existed long prior to their discovery.

Since it was proved by the analysis that tularemia persists in specific areas, it is clear that it is a disease occurring in natural foci. Knowledge on the general environmental conditions and geographic distribution of existing natural foci of tularemia makes it possible to predict the possible occurrence of tularemia in other suitable areas where it has not yet been found because, for example, no one tried. It is also possible to use this knowledge for the purpose of preventive and control measures such as banning transfer of wild animals from areas of existing natural foci to geographic areas which are prone to become natural foci.

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