Epidemiological surveillance of rabies in Lithuania from 1986 to 1996

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Summary
Rabies has been endemic in Lithuania for centuries. The objective of this study was to evaluate rabies incidence and seasonal trends in domestic and wild animals in Lithuania from 1986 to 1996. Annual rabies reports and data on cattle numbers were collected. Descriptive epidemiology and time series data analyses were performed to detect seasonal trends. A total of 1,475 specimens were submitted for rabies testing. Of these, 1,248 (84.6%) were confirmed as rabies cases by immunofluorescence antibody testing. Domestic animals accounted for 73.8% (921/1,248) of all rabies cases, with cattle accounting for 61.1% (563/921) of domestic animal cases. Wildlife cases were reported principally in red foxes (56%; 183/327) and raccoon dogs (31.2%; 102/327).

Time series analysis indicated a strong association between the occurrence of rabies in cattle and the season of the year ($P = 0.0032$), with the highest incidence of rabies occurring in autumn. The incidence declined from 3.4 to 4.8 cases per 100,000 cattle in the mid-1980s to <1.5 cases per 100,000 cattle in 1994, but increased to 4.2 cases per 100,000 cattle in 1996. However, as the cattle population dramatically decreased (by 54%) over the eleven-year period of the study, the reduction in the total number of rabies cases in cattle was not reflected in the annual incidence rate of cattle rabies.

Keywords

Introduction
Rabies has been reported in Lithuania in official documents since the 15th century (10). Animals and humans were infected primarily with urban dog rabies. In 1897, the first Pasteur Treatment Centre was established in Vilnius to vaccinate humans against rabies (7). In 1933, the Lithuanian Veterinary Academy was established in Kaunas and since then rabies laboratory diagnosis (histopathology, mouse inoculation and immunofluorescent antibody test) has been performed on animals suspected to have the disease. Since 1965, rabies vaccination of dogs has been compulsory and approximately 130,000 dog vaccinations are performed annually. This represents no more than 30% of the estimated dog population. Since the introduction of dog vaccinations, more rabies cases have been reported in cattle than in dogs each year.

Rabies poses a threat to both animals and humans. During the last eleven years, three people have died of rabies: two were infected by dogs (one case in 1992 and one case in 1993) and one by a raccoon dog (Nyctereutes procyonoides) (in 1992). Thus, there is a need to evaluate the current situation to establish appropriate rabies control measures in wildlife and in domestic animals. In recent years, the risk to humans has increased, as the number of human medical visits after contact with rabies-suspect animals increased by 150% in Lithuania (approximately 3,000 medical visits in 1989 and
7,000 medical visits in 1993). However, the number of post-exposure treatments remained almost at the same level, affecting 75% to 80% of the people visiting the centres (19).

As in most of Europe, the main wildlife reservoir of rabies in Lithuania is the red fox (Vulpes vulpes) (9). The emergence of a new reservoir, the raccoon dog, has been reported in Eastern and Central Europe, including Lithuania (6, 19). Rabies is more widespread in wooded areas, and the density of foxes and raccoon dogs is estimated to be 6 to 12 animals per 1,000 ha (13).

New generations of vaccines against rabies have proved to be efficient and safe (15) when introduced into various countries and climates (4, 5, 17). Between 1965 and 1990, rabies vaccines produced in Russia were used for immunisation of domestic animals. Since 1991, most rabies vaccines for domestic animals (cell culture inactivated and adjuvanted vaccines) have been imported from France. Recent studies showed oral vaccination of foxes to be more effective in reducing rabies incidence than depopulation of foxes (1, 3). Between 1983 and 1986, oral vaccination of a limited number of foxes (277), raccoon dogs (73) and badgers (14) was initiated as a pilot measure to control rabies in wildlife species in seven high-incidence foci in five districts (13, 19). Vaccines produced from a live modified virus (a Vnukovo derivative called EVMTI-VVMKI-71: a hamster cell line, adapted ERA [Evelyn-Rokitnicki-Abelseth] derivative), injected in fish pieces or minced meat, were used in these campaigns (13, 19). With these measures, a 25% to 50% reduction in animal rabies cases was reported in these districts (7, 9). However, this rabies control measure was ended in 1989 because of economic constraints.

The objective of the study was to describe rabies incidence and trends in domestic and wild animals in Lithuania for the eleven-year period between 1986 and 1996. Temporal fluctuations were analysed to determine if seasonal patterns existed in reported rabies incidence, and to verify the association between rabies in wildlife and in domestic animals. The study also examined which districts were most affected over time. Based on these findings, the authors assessed the need for modifications in rabies control measures.

Materials and methods

Data sources

Rabies cases
Control of rabies is under the supervision of the State Veterinary Service (the former Veterinary Department within the Ministry of Agriculture). There are 44 administrative districts in Lithuania, each with a branch office of the State Veterinary Service (SVS). Disease occurrence is reported monthly to the animal health department in Vilnius (SVS headquarters). Rabies is clinically diagnosed by qualified and licensed veterinarians and brain samples from suspected cases are sent to the National Veterinary Laboratory for confirmation of diagnosis by either immunofluorescence antibody test or histopathologic examination (for animals not reported to have had contact with humans or domestic animals) (16, 19). In general, all suspect animals are reported, but priority is given to animals associated with human and domestic animal exposure. Annual summaries of reported and confirmed rabies cases from the Lithuania SVS were obtained for the period 1986 to 1996, as well as the numbers of animals submitted for rabies testing. Only laboratory-confirmed cases were included in the analysis.

Cattle population census data
Annual vaccinations and herd-testing reports for state prophylaxis allowed the authors to accurately estimate the cattle population in Lithuania. Cattle census data were available from the Ministry of Agriculture and were linked to these data to evaluate the annual incidence of rabies. The number of cattle in Lithuania remained at approximately 2.4 million from 1986 until 1990, but then numbers decreased dramatically across the country to 1.1 million in 1996, mainly because of economic changes, especially the transition from central planning to a free-market economy.

Data analysis

Confirmed rabies cases were grouped according to the species, geographical location (44 districts) and month of occurrence (laboratory confirmation). Maps of the geographical location of reported rabies cases in different species (cattle, dogs and cats, foxes and raccoon dogs) were generated for every year.

Incidence calculation
Quarterly and yearly rabies incidences in cattle were tabulated. The incidence was calculated for cattle only, as this was the sole animal species for which reliable demographic data were available. For quarterly incidence figures, it was assumed that the population increase or decline was evenly distributed throughout the year. Therefore, the yearly decrease was equally divided over the four quarters. For comparisons of seasonal trends in rabies incidence in cattle, the months were grouped into four seasons (quarters), as follows:
- January to March
- April to June
- July to September
- October to December.

Statistical analysis
The difference in rabies prevalence in raccoon dogs between the two periods of 1986 to 1990 and 1991 to 1996 was evaluated with a chi-square test to detect trends, using Epi Info 6.04a software. Time series analysis using Minitab software was performed to evaluate the relationship between
time (season) and rabies incidence in cattle. Seasonal trends and seasonal autocorrelation were calculated and statistical significance was evaluated by t-test (8). The autocorrelation function (ACF) employed generates the correlation co-efficient r, a measure of linear relationship between time series observations separated by a lag of k (time unit). This function gives a mean of testing for the significance of seasonality in a time series by examining the ACF at seasonal matching quartets (lags 4). Correlation co-efficients are typically evaluated by a t-test. However, when the sample size is large (n > 30), a z-test can be used and gives equivalent results. The incidence in different seasons during the eleven-year period was compared using time indices.

Results

During the period 1986 to 1996, Lithuania experienced a high frequency of reported rabies cases in all susceptible species. A total of 1,475 specimens were submitted for rabies testing. Of these, 1,248 (84.6%) were confirmed to be rabies cases by the immunofluorescence antibody test, with 73.8% of confirmed rabies samples among those testing. Of these, 1,248 (84.6%) were confirmed to be rabies cases, whereas they accounted for only 24.1% (35/145) of all wildlife cases between 1991 and 1996, a difference that was statistically significant (odds ratio [OR] = 1.8; 95% confidence interval [CI] = 1.1-3.1).

The percentage of confirmed rabies samples among those submitted for rabies testing averaged 85% (range: 77% in 1994 to 90% in 1990). No significant differences in prevalence were observed during the eleven-year period for cattle, dogs and foxes. However, raccoon dog samples were more likely to give positive results during the 1986 to 1990 period than in the 1991 to 1996 period (OR = 2.7; 95% CI = 1.1-6.6).

During the eleven-year period, the geographical distribution of reported rabies cases shifted from the south-east and north-east regions to the north-west of Lithuania (Fig. 1). For raccoon dogs, most cases reported in the 1980s were observed in the eastern part of the country, with a progressive shift over the years from east to west. A second wave of raccoon dog rabies was also observed in the 1990s from east to west (data not shown).

The total number of reported rabies cases decreased from 168 cases in 1986 and 174 cases in 1987 to 78 cases in 1995 and 108 cases in 1996, the lowest occurring in 1991 (64 cases) (Table I). Accordingly, the number of reported rabies cases in cattle decreased from 82 cases in 1986 and 117 cases in 1987 to 29 cases in 1995 and 46 cases in 1996, with the lowest number of 17 cases occurring in 1994. There was no consistent trend in reported rabies cases in dogs, cats and foxes. There were two major peaks of rabies incidence in cattle, one in 1987 (4.9 cases/100,000 cattle) and another in 1996 (4.2 cases/100,000 cattle). The lowest incidence rates occurred in 1989 and 1994 (1.2 cases/100,000 cattle). In

Table I

Reported rabies cases in Lithuania from 1986 to 1996

<table>
<thead>
<tr>
<th>Year</th>
<th>Dogs</th>
<th>Cats</th>
<th>Cattle</th>
<th>Other</th>
<th>Total no. cases in domestic animals</th>
<th>Foxes</th>
<th>Raccoon dogs</th>
<th>Martens</th>
<th>Other</th>
<th>Total no. cases in wild animals</th>
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</thead>
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<tr>
<td>1986</td>
<td>17</td>
<td>15</td>
<td>82</td>
<td>2</td>
<td>117</td>
<td>28</td>
<td>2</td>
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<td>1987</td>
<td>25</td>
<td>5</td>
<td>117</td>
<td>2</td>
<td>145</td>
<td>16</td>
<td>9</td>
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<td>1988</td>
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<td>76</td>
<td>3</td>
<td>120</td>
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<td>13</td>
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<td>1989</td>
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<td>65</td>
<td>2</td>
<td>103</td>
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<td>9</td>
<td>1</td>
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<td>27</td>
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<tr>
<td>1991</td>
<td>18</td>
<td>5</td>
<td>31</td>
<td>1</td>
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<td>1992</td>
<td>19</td>
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<td>70</td>
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<td>1995</td>
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<td>3</td>
<td>70</td>
<td>25</td>
<td>7</td>
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<td>1</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>186</td>
<td>153</td>
<td>563</td>
<td>19(a)</td>
<td>921</td>
<td>183</td>
<td>102</td>
<td>27</td>
<td>15(b)</td>
<td>327</td>
</tr>
</tbody>
</table>

(a) Horses: 7 cases; pigs: 4 cases; sheep: 3 cases; goats: 3 cases; rabbits: 1 case; donkeys: 1 case
(b) Field cats: 4 cases; badgers: 3 cases; elk: 3 cases; wolves: 2 cases; roe-deer: 2 cases; lynxes: 1 case
addition, there were smaller peaks in 1990 (2.7 cases/100,000 cattle) and 1993 (2.2 cases/100,000 cattle) (Fig. 2).

The distribution of rabies cases varied by season in cattle (Fig. 3a), foxes and raccoon dogs (Fig. 3b). A peak of reported rabies cases in cattle occurred in October and November. There were two peaks of reported rabies cases in foxes and raccoon dogs: the first in January to March, and the second in September to November. In raccoon dogs, the peaks were...
observed in January and October whereas, in foxes, the peaks occurred in March and in September to October. No specific seasonal peak was observed for dogs whereas, in cats, peaks were observed in February, September and December.

The reported rabies incidence in cattle differed from season to season and was below expected values in the first semester and above expected values during the second semester. The incidence was highest during the fourth quarter (October to December), in comparison to other seasons (Fig. 4). Seasonal indices were as follows:
- season (quarter) 1: -0.00026
- season 2: -0.00030
- season 3: 0.000135
- season 4: 0.000428.

The overall accuracy of the model was good and the autocorrelation function yielded a value of 2.87 (P = 0.0032), indicating a significant relationship between season and rabies incidence in cattle.

Discussion

Lithuania has endemic rabies in both domestic animals and wildlife. Between 1986 and 1996, more than 1,200 cases were diagnosed, with 74% of these cases affecting domestic animals, mainly cattle. These data indicate that rabies surveillance is addressing the problem principally in domestic animals, with very limited emphasis on the wildlife reservoir. This observation is supported by the fact that such results are in contrast with data reported from most of western and central Europe, where wildlife rabies accounts for approximately 75% of confirmed rabies cases, with foxes being the main species affected (11). For instance, in 1994, of 2,273 rabies cases reported in Poland, 79% were reported in wildlife and, of those cases, foxes accounted for 84% (14). In countries affected with urban rabies, dogs account for most of the rabies cases and < 10% of cases are observed in cats or cattle (18). As cases in domestic carnivores in Lithuania accounted for only 27% of the total number of cases, the epidemiology of rabies in Lithuania, as in most of Europe, appears to be centred on wildlife reservoirs, principally foxes and raccoon dogs (11). For most foci of rabies in this study, domestic animal cases were usually associated with few reports in wildlife. The present data strongly indicate a major under-reporting of this disease in wildlife. Increased disease surveillance in wildlife would seem warranted, especially if rabies prevention measures are to target wildlife immunisation.

The relatively recent emergence of a second wildlife reservoir, the raccoon dog, is of epidemiological importance. The raccoon dog was originally found in the far East (Japan, Korea, China and Siberia). In the 1930s and 1940s, thousands of raccoon dogs were imported to augment numbers of local fur-bearing animals in eastern Russia. The distribution of the raccoon dog now ranges from the European region of Russia to the Baltic republics, Poland and Finland. Raccoon dogs have also been seen in Germany and France. In Finland, an epidemic of wildlife rabies occurred among raccoon dogs in 1988. The raccoon dog population increased greatly in Finland from the late 1960s and reached its highest level by the mid-1980s (12). As indicated by Cherkasskiy (6), the most affected districts of Poland in the 1980s bordered the Baltic republics. During these years, there has been a tendency for the prevalence of rabies in raccoon dogs in the north-east of Poland to increase faster than that in foxes (6).

Based on the limited data of the authors, such a phenomenon does not seem to have occurred in Lithuania, indicating either a different cycle in that species in the Baltic republics or an inadequate surveillance system. However, it is noticeable that the total number of rabies cases in raccoon dogs declined significantly in Lithuania between 1991 and 1996, compared with that of 1986 to 1990. Similarly, this decline in the numbers of rabid raccoon dogs was associated with a decline in the prevalence of positive samples during the same period, supporting the hypothesis of a major raccoon dog rabies epidemic in Lithuania in the 1980s, which receded during the first part of the 1990s.

An apparent decline in the number of cases in domestic cattle was misleading and was related to the concurrent decrease in the cattle population from 2.4 million head of cattle in 1986 to 1.1 million in 1996. Time series analysis of rabies incidence in cattle showed no decreasing trend, a finding which indicates the need for more stringent rabies control measures. In most of western Europe, the introduction of wildlife vaccination has led to a dramatic decrease of rabies cases in both domestic and wild animals. The recent increase of rabies incidence in cattle in Lithuania indicates that the situation has probably worsened in the wildlife reservoir and that urgent action is needed to reduce disease occurrence in domestic animals and in humans.
Analysis of both reported cases and incidence revealed a strong seasonal trend of rabies in cattle. The greatest number of reported cases and the highest incidence were observed during the October to December period, followed by the July to September period. As the rabies incubation period in cattle is estimated to average two to three months (range: 25-152 days) (2), the time of greatest risk of cattle being infected by a rabid animal may occur between early July and late September, when most cattle are grazing in the pastures and may be left in the fields overnight.

During the eleven-year period, the distribution of rabies cases seems to have shifted from the south-eastern region of the country to the north-western part of Lithuania. However, there were no specific geographical or economic reasons to explain such a trend.

The hunting season for foxes and raccoon dogs is not restricted in Lithuania but, as in other countries, this measure does not efficiently reduce wildlife populations. In Finland, it was estimated that a density of 0.45 to 1.3 animals per square kilometre in mixed fox-raccoon dog populations was above the rabies transmission threshold (12). Introducing vaccination of cattle in the high-risk areas or oral vaccination of foxes and raccoon dogs should therefore be considered, as an oral rabies vaccination campaign successfully controlled an outbreak of rabies in raccoon dogs in Finland (12). Similarly, mandatory rabies vaccination of pets should be strictly enforced to increase the percentage of immunised cats and dogs.

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Surveillance épidémiologique de la rage en Lituanie, de 1986 à 1996

L. Gylys, B.B. Chomel & I.A. Gardner

Résumé

En Lituanie, la rage sévit à l’état endémique depuis des siècles. Une enquête en vue d’évaluer l’incidence et les variations saisonnières de la maladie chez les animaux domestiques et sauvages dans ce pays a été conduite de 1986 à 1996. Elle a permis de recueillir des informations annuelles sur cette maladie ainsi que sur les populations de bovins. L’épidémiologie descriptive et l’analyse chronologique des données ont mis en évidence des tendances saisonnières. Parmi les 1 475 prélèvements analysés, 1 248 (84,6 %) contenaient du virus de la rage révélé par la technique de l’immunofluorescence. Les animaux domestiques représentaient 73,8 % (921/1 248) de l’ensemble des individus atteints, dont 61,1 % (563/921) de bovins. Parmi les animaux sauvages, la maladie a été signalée essentiellement chez le renard roux (56 % ; 183/327) et le chien viverrin (31,2 % ; 102/327).

L’analyse chronologique des données révèle l’existence d’une étroite corrélation entre la fréquence de la rage chez les bovins et la saison ($P = 0,0032$), l’incidence la plus forte se situant en automne. L’incidence a reculé, passant de 3,4 à 4,8 cas
pour 100 000 bovins, au milieu des années 1980, à moins de 1,5 cas pour 100 000 bovins en 1994 ; en 1996 elle a de nouveau augmenté, atteignant 4,2 cas pour 100 000 bovins. Cependant, comme le cheptel bovin a considérablement diminué (54 %) pendant les onze années au cours desquelles s’est déroulée l’étude, le taux d’incidence annuelle de la rage bovine ne reflétait pas la réduction du nombre total de cas chez les bovins.

Mots-clés

Vigilancia epidemiológica de la rabia en Lituania entre 1986 y 1996

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Resumen
La rabia es endémica en Lituania desde hace siglos. Los autores presentan un estudio que tenía por objetivo analizar la incidencia y las pautas estacionales de la rabia en animales domésticos y salvajes de Lituania entre 1986 y 1996. Se recopilaron informes anuales sobre la rabia y datos sobre la población de bovinos. Para determinar las tendencias estacionales de la enfermedad se analizaron datos tanto de epidemiología descriptiva como cronológicos. Se sometieron a prueba un total de 1.475 muestras, 1.248 de las cuales (un 84,6%) se confirmaron como casos de rabia aplicando un ensayo de detección de anticuerpos por inmunofluorescencia. Los animales domésticos daban cuenta del 73,8% (921/1.248) de los casos de rabia. De entre los animales domésticos, un 61,1% (563/921) de los casos correspondía a ganado vacuno. Según los informes, los animales salvajes más afectados resultaron el zorro (56%; 183/327) y el perro mapache (31,2%; 102/327).

El análisis de las secuencias temporales puso de manifiesto una estrecha correlación entre la aparición de rabia en el ganado vacuno y la estación del año ($P = 0,0032$), con el otoño como estación de mayor incidencia. La incidencia cayó desde los 3,4-4,8 casos por 100.000 cabezas de ganado que se registraban a mediados de los años ochenta hasta los menos de 1,5 casos por 100.000 cabezas en 1994, aunque en 1996 volvió a aumentar hasta 4,2 casos por cada 100.000 cabezas. Sin embargo, mientras que la población vacuna se redujo drásticamente (54%) durante el periodo de once años que duró el estudio, la caída del número total de casos de rabia en el ganado no tuvo reflejo en la tasa de incidencia anual.

Palabras clave
References