Epidemiology and control of rabies in the Alpine areas: the case of Italy*

S. PROSPERI**, A. GIOVANNINI*** and L. PAULUCCI DE CALBOLI**

Summary: The epidemiological status of sylvatic rabies in Italy between 1977 and 1985 is described, particularly with regard to the number of animals tested and the number of positives, divided according to their different species; special reference is also made to the geographical diffusion of the disease, depicted in a series of maps. The influence of biological characteristics of wild carnivores (especially the fox) on the epidemiological pattern of rabies in Europe is taken into account, with emphasis on the Italian situation. An assessment of the fox population in the Italian Alpine regions is derived from the number of foxes shot per km² during 1983 and 1984. The control measures enforced in Italy are discussed on the basis of their actual results and costs, and with a view to more effective planning and implementation.

KEYWORDS: Biology - Disease control - Dogs - Domestic animals - Epidemiology - Fox - Italy - Rabies - Vaccination - Wild animals.

INTRODUCTION

Two epidemiological types of rabies are recognized:

a) *Urban rabies*, associated with domestic animals, especially dogs, and with stray animals. This form existed in Italy until 1973. Its eradication was attained by vaccinating all owned dogs over the entire national territory during 1969 and 1970 and, subsequently, only in some provinces at risk (in 1971, 1973, 1974 and 1975). This was also obtained through direct prophylactic measures, such as the capture of stray dogs. Italy was free from rabies between 1973 and the appearance of sylvatic rabies in 1977.

b) *Sylvatic rabies*, associated with wild animals, especially red foxes (*Vulpes vulpes*), entered Italy in February 1977 in the Aurina Valley, Bolzano Province. It originated in Poland, during World War II, from an outbreak involving foxes. From this primary outbreak, the epidemic spread south and west at a rate of about 40 km a year involving the German Democratic Republic, the German Federal Republic, Czechoslovakia, Hungary, Belgium, Luxemburg, Holland, Denmark, Yugoslavia, Austria, Switzerland, France and Italy.

In this present account, the biology of wild carnivores is discussed with special reference to the fox, and general consideration is given to the epidemiology of

---

* This research was supported by Consiglio Nazionale delle Ricerche, Progetto Finalizzato “Controllo malattie da infezione”, Sottoprogetto “Epidemiologia”.
** Istituto di Malattie Infettive, Profilassi e Polizia Veterinaria, Via San Giacomo 9/2, Università di Bologna, Italy.
*** Istituto Nazionale di Biologia della Selvaggina, Ozzano-Bologna, Italy.
sylvatic rabies in relation to the Italian situation. This is followed by a discussion of the spread of wildlife rabies in Italy from its entry up to the present time, taking into account the control measures enforced in Italy.

**BIOLOGY OF WILD CARNIVORES IN RELATION TO THE EPIDEMIOLOGY OF RABIES**

Important factors influencing the epidemiology of wildlife rabies in Europe are the population dynamics and social behaviour of foxes. They are related to the high degree of adaptability of this animal, which is capable of living and breeding in different environments. Its feeding habits are extremely wide and adaptable to different local conditions, so that the fox may feed on any edible material. Only in the presence of abundant food does it exhibit feeding preferences. As a rule, the fox has a very broad ecological niche characterized by marked opportunism. Similarly, the social organization of this animal is extremely flexible and varies according to the food availability and different habitats.

Since the earliest investigations of wildlife rabies, the fox population density has been regarded as a factor of crucial significance. In fact, for rabies to become endemic in a given geographical area, the local fox population density needs to be at least 0.25-1.0 fox/km² (1). Others authors (36) have shown that the disease becomes endemic with "Hunting Indicator of Population Density" (HIPD) values of 0.3-0.4 fox/km².

Indirect investigations in continental Europe have demonstrated that in rabies-free flat and hilly land, in the absence of any control measures, the HIPD ranges from 0.8 to 6 foxes/km²; conversely, in the Alpine regions these values decline progressively with increasing altitude and snow precipitation (36).

The discrepancies seen in fox population densities in the absence of rabies in different habitats also imply differences in population dynamics, which govern the epidemiological pattern upon arrival of the disease. Thus, when the fox density is below the minimum threshold required for the spread of the disease, the epidemic becomes extinct due to low chances of an infected fox meeting a susceptible one, assuming that the former is a carrier capable of shedding rabies virus (10). With higher population densities, after a drop in density corresponding to the epidemic outbreak, a subsequent endemic stage follows, with either an oscillatory course (lasting 3 to 5 years) of both population density and disease occurrence (10, 38), or rabies persists indefinitely at low incidence without defined peaks.

A reasonable explanation of how fluctuations of fox density and rabies incidence develop is provided by Steck and Wandeler (36). After the initial epidemic wave has passed, a sharp drop in the fox density occurs, particularly where it was high before the introduction of the infection. However, the reduction and subsequent recovery of the original density is not uniform in all areas; in endemic zones a mosaic of small districts is found with populations of differing densities (below or above the threshold value) in which scattered rabies foci persist, capable of giving rise to new epidemic waves.

Some mathematical models have been proposed recently to analyse and/or simulate epidemic patterns in different situations in order to obtain better information concerning the quantitative aspects of wildlife rabies epidemiology (28, 1, 19, 20, 21, 3). One such method, developed by Anderson et al. (1), fits the pattern of
rabies spread and may explain the course of the epidemic in Europe. With this model, the population density is considered as a dynamic variable influenced by both the disease and other density-dependent constraints. The fundamental parameter in the description of rabies epidemiology, therefore, is the "Fox Carrying Capacity" (FCC), i.e. the fox density which a certain environment can sustain in equilibrium.

Upon introduction of rabies into a fox population, three different regimes of population are formed:

a) With FCC values below the transmission threshold (0.25-1.0 fox/km²), the disease disappears.

b) With densities above the threshold, rabies behaves as a density-dependent constraint having a delayed effect that results in oscillations of the population dynamics. In the presence of high population densities, stable oscillations occur at cycles of 3 to 5 years, their duration and amplitude depending upon FCC values.

c) With low FCC values, the oscillations are less pronounced.

Also, rabies epidemiology is influenced by the territorial organization and social behaviour of the fox. In general, a fox population consists of resident and itinerant members. The resident members are organized into family territories which are defended against intruders.

The sizes of the territories, and the groups inhabiting a certain area, vary considerably according to the availability and dispersion of food resources (i.e. the dispersion of the habitats of individual prey species or of edible refuse of human origin) within the home range of a fox group. The main factor influencing the size of the territory of a family group is the dispersion of food resources, whilst the number of individuals forming a group is limited by the availability of food at the feeding sites (23). This affects the frequency of encounters of each fox, and accounts for differences in sylvatic rabies epidemiology which are found in different areas. Thus the infection spreads more readily among members of the same family group, whereas the transmission to other groups is encouraged by the presence of numerous groups consisting of four or more individuals. Also the size of territory may influence the frequency of encounters among foxes; the information available on this aspect, though limited, suggests that the distances covered by young foxes during dispersal, and hence the opportunities for encounters, are more likely with increasing average sizes of the home ranges in a given area (24). The influence of the characteristics of habitats on rabies epidemiology was also pointed out by Zimen (43) and Ball (4).

The progression of the initial wave, however, is also influenced by both natural and artificial barriers (more numerous in Italy in the Alpine regions than in continental Europe) which may serve as channels and/or obstacles. Thus, an Alpine valley allows good longitudinal, but not transverse, dispersal. Similarly, a river or a large communication line represent an obstacle when at right angles to the initial wave. For these reasons, speeds of advance in Italy varied from 20 to 80 km/year, compared with 30-50 km in continental Europe (Fig. 1).

Rabies virus has a genetic plasticity which enables it to respond to selection pressures, and to give rise to various ecotypes/populations adapted to particular animal communities and landscapes. This results in the existence of several rabies-host associations (17, 8). There is also circumstantial evidence for changes in rabies-host
FIG. 1
Rabies spread in Italy between 1977 and 1985
associations (17). Such changes have been studied in detail in eastern USA, where shifts in the species playing the most important epidemiological role (from dogs to red foxes to skunks) have been reported (16). In Europe no carnivore, other than the red fox, is involved (25).

Unlike the fox, other species of wild carnivores are of little significance in sylvatic rabies epidemiology and represent only an epiphenomenon of the cycle which is invariably based upon fox reservoirs. These animals, especially the badger (Meles meles) and the stone marten (Martes foina), show an increased rabies incidence soon after the epidemic wave has moved through the area. This could be due to a longer incubation period of the disease in these species and to exposure occurring during the final phase of the incidence peak, rather than to the development of infection chains within the populations of these mustelids; indeed, short-term chains have been described only in the badger. Concurrent with an increased incidence among mustelids, a higher occurrence is seen in wild herbivores (e.g. roe deer) and in domestic ones (36, 2).

A different situation is found in Italy concerning stray and feral dogs. In fact, the density of these animals in the Apennines is such as to preclude any forecast should these areas be reached by a sylvatic rabies epidemic (6). Thus, although it has been stated that rabies in species other than reservoirs represents an epidemiological epiphenomenon, there are some exceptions to this general rule. For instance, in Africa, rabies has dogs and jackals as a common reservoir; in the Arctic regions foxes and wolves; in Iran wolves, dogs and possibly also foxes (11).

DIFFUSION OF THE FOX IN THE ALPINE AREA

At present, the exact density of the fox population is unknown, even though some data are available on the fox distribution in Italy (30, 12). Thus, in the absence of reliable data from censuses (which are difficult to take in such extensive areas as those involved by wildlife rabies) the index of relative abundance is generally provided by the "Hunting Indicator of Population Density" (HIPD), i.e. the number of foxes shot yearly per km$^2$. This "indicator" has defects which should always be allowed for. First, it mirrors not only the actual population density but also the relative hunting pressure. In consequence, it may be reliable only when the hunting pressure tends to remain constant. Also, it provides useful information about changes in the population density within a determined area, but a comparison of the HIPD in different areas would be of no significance (9).

As far as Italy is concerned, the HIPD does not fit because of the peculiar Alpine geographical features and difficulties in maintaining a constant hunting pressure. Data on the number of foxes shot per km$^2$ are available for 1983 and 1984. These data are reported in Table I, and have been calculated for infected and at-risk municipalities (in the different provinces), i.e. where the fox population is being thinned out in an attempt to control the spread of rabies. These territories do not include those municipalities situated in the Stelvio and Gran Paradiso National Parks, where any form of animal shooting is forbidden; other areas were also excluded in which the foxes have no chance of survival, as marked on a map of soil utilization in mountain areas (Ministry of Agriculture, 1975), i.e. uncultivated barren land, rocky zones with glaciers and strictly urban and industrial areas. These data immediately reveal the existence of marked differences in the degree of fox
TABLE I
Numbers of and premiums for foxes shot in the Alpine provinces during the years 1983 and 1984

<table>
<thead>
<tr>
<th>Province</th>
<th>Fox population thinning area in km²</th>
<th>Foxes shot during 1983</th>
<th>Foxes shot during 1984</th>
<th>Premium $US/fox</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aosta</td>
<td>1972</td>
<td>65</td>
<td>117</td>
<td>6.67</td>
</tr>
<tr>
<td>Torino</td>
<td>806</td>
<td>25</td>
<td>21</td>
<td>6.67</td>
</tr>
<tr>
<td>Novara</td>
<td>2476</td>
<td>2</td>
<td>2</td>
<td>6.67</td>
</tr>
<tr>
<td>Sondrio</td>
<td>2237</td>
<td>586</td>
<td>301</td>
<td>67</td>
</tr>
<tr>
<td>Varese</td>
<td>573</td>
<td>99</td>
<td>119</td>
<td>67</td>
</tr>
<tr>
<td>Como</td>
<td>1128</td>
<td>382</td>
<td>469</td>
<td>67</td>
</tr>
<tr>
<td>Bergamo</td>
<td>1021</td>
<td>238</td>
<td>253</td>
<td>67</td>
</tr>
<tr>
<td>Brescia</td>
<td>1622</td>
<td>400</td>
<td>591</td>
<td>67</td>
</tr>
<tr>
<td>Trento</td>
<td>5333</td>
<td>369</td>
<td>723</td>
<td>67</td>
</tr>
<tr>
<td>Bolzano</td>
<td>5462</td>
<td>894</td>
<td>1085</td>
<td>47</td>
</tr>
<tr>
<td>Belluno</td>
<td>3257</td>
<td>665</td>
<td>652</td>
<td>33</td>
</tr>
<tr>
<td>Udine</td>
<td>2898</td>
<td>263</td>
<td>179</td>
<td>33</td>
</tr>
<tr>
<td>Gorizia</td>
<td>424</td>
<td>74</td>
<td>49</td>
<td>33</td>
</tr>
<tr>
<td>Trieste</td>
<td>162</td>
<td>29</td>
<td>33</td>
<td>33</td>
</tr>
</tbody>
</table>

population reduction, since the particularly low values recorded in some provinces are not, in our opinion, justified by environmental situations which could prevent the presence of foxes. Secondly, in almost all of the Alpine areas involved, these data confirm the presence of fox population densities sufficient to allow the persistence of the rabies cycle.

EPIDEMIOLOGICAL PATTERN AND SPREAD OF RABIES IN ITALY

The epidemiological pattern of rabies in Italy is reported in Table II, where positive animals are listed according to species and yearly incidence.

The spread of rabies in Italy, from its entrance in 1977 in Bolzano Province up to 1985, is depicted by maps (Figs. 2, 3, 4), each map representing three years' occurrence of the disease.

In those provinces where the disease is still endemic, mosaic-like foci are found, as already described by Steck and Wandeler (36).

For a better understanding the data are discussed year by year.

1977

Rabies entered Italy during February through the Krimml Pass at the Austrian border; the first cases were reported in foxes in Aurina Valley (in the municipality of Predoi, Bolzano). The disease was diagnosed in ten municipalities covering an area of 1126 km², in Bolzano Province. Nine municipalities are situated in Aurina Valley; during November rabies was diagnosed in Casies Valley; this outbreak was not related to others and indicated, therefore, a second entrance from Austria.

1978

The epidemic wave moved south-west to involve 10 municipalities in the Bolzano Province (766 km²) and 6 municipalities in the Belluno Province (641 km²) for
### TABLE II

**Number of positive results of tests for rabies among animals in the Alpine regions (1977-1985)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wild animals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Badger</td>
<td>5/56</td>
<td>27/184</td>
<td>10/65</td>
<td>2/46</td>
<td>23/151</td>
<td>31/132</td>
<td>22/131</td>
<td>20/113</td>
<td>11/89</td>
<td>151/968</td>
</tr>
<tr>
<td>Other mustelids</td>
<td>0/31</td>
<td>1/89</td>
<td>0/47</td>
<td>0/42</td>
<td>13/295</td>
<td>10/298</td>
<td>9/420</td>
<td>9/423</td>
<td>3/331</td>
<td>45/1976</td>
</tr>
<tr>
<td>Squirrel</td>
<td>0/9</td>
<td>0/12</td>
<td>0/7</td>
<td>0/2</td>
<td>0/22</td>
<td>0/21</td>
<td>1/90</td>
<td>0/0</td>
<td>0/15</td>
<td>1/178</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td><strong>99/2181</strong></td>
<td><strong>249/3457</strong></td>
<td><strong>78/2326</strong></td>
<td><strong>12/2230</strong></td>
<td><strong>363/5131</strong></td>
<td><strong>439/5444</strong></td>
<td><strong>437/6216</strong></td>
<td><strong>118/5691</strong></td>
<td><strong>2042/37510</strong></td>
<td><strong>123/6047</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Domestic animals</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dog</td>
<td>0/89</td>
<td>0/182</td>
<td>0/175</td>
<td>0/184</td>
<td>0/423</td>
<td>4/426</td>
<td>4/408</td>
<td>4/463</td>
<td>1/411</td>
<td>13/2761</td>
</tr>
<tr>
<td>Cat</td>
<td>0/75</td>
<td>1/215</td>
<td>0/110</td>
<td>0/77</td>
<td>2/468</td>
<td>3/460</td>
<td>3/498</td>
<td>2/501</td>
<td>2/385</td>
<td>13/2789</td>
</tr>
<tr>
<td>Cattle</td>
<td>0/20</td>
<td>0/7</td>
<td>0/142</td>
<td>0/8</td>
<td>2/39</td>
<td>0/23</td>
<td>0/22</td>
<td>1/26</td>
<td>1/23</td>
<td>4/310</td>
</tr>
<tr>
<td>Sheep</td>
<td>0/1</td>
<td>0/5</td>
<td>0/10</td>
<td>0/6</td>
<td>0/8</td>
<td>1/39</td>
<td>1/28</td>
<td>0/25</td>
<td>0/3</td>
<td>2/125</td>
</tr>
<tr>
<td>Goat</td>
<td>0/1</td>
<td>0/0</td>
<td>1/3</td>
<td>0/0</td>
<td>0/6</td>
<td>0/0</td>
<td>0/13</td>
<td>0/11</td>
<td>0/20</td>
<td>1/54</td>
</tr>
<tr>
<td>Horse</td>
<td>0/0</td>
<td>0/3</td>
<td>0/0</td>
<td>0/1</td>
<td>0/0</td>
<td>0/2</td>
<td>1/2</td>
<td>0/0</td>
<td>0/0</td>
<td>1/8</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td><strong>0/186</strong></td>
<td><strong>1/412</strong></td>
<td><strong>1/440</strong></td>
<td><strong>0/276</strong></td>
<td><strong>4/944</strong></td>
<td><strong>8/950</strong></td>
<td><strong>9/971</strong></td>
<td><strong>7/1026</strong></td>
<td><strong>4/842</strong></td>
<td><strong>34/6047</strong></td>
</tr>
</tbody>
</table>

| **Total**        | **99/2367** | **250/3869** | **79/2766** | **12/2506** | **367/6075** | **345/5783** | **448/6415** | **354/7242** | **122/6533** | **2076/43557** |

* *Number of positives/tested.*
FIG. 2
Occurrence of rabies in Italy during 1977, 1978, 1979
FIG. 3
Occurrence of rabies in Italy during 1980, 1981, 1982
FIG. 4
Occurrence of rabies in Italy during 1983, 1984, 1985
the first time. During August, rabies was reported in a fox in Vizze Valley (Bolzano), unconnected with the main wave but associated with the actual epidemic in North Tyrol (Austria); after this report no additional cases were found. During November the disease was reported in the Udine Province, at the Austrian border (Carinthia), involving 4 municipalities encompassing 506 km².

1979

On the whole, a decreased occurrence was recorded, with only four cases being reported in the last quarter. However, the epidemic advanced in Udine Province where eight municipalities were involved covering 318 km².

1980

The decrease in the number of cases became more obvious in the previously infected areas. In Udine Province six additional municipalities were involved for the first time (382 km²). During October rabies moved into the western part of Bolzano Province, Venosta valley, from North Tyrol through the Resia Pass. The disease also entered from the Swiss canton of Grigioni by way of the Slingia Pass and hit two municipalities (457 km²).

1981

A marked increase in disease occurrence was recorded. By the end of this year four regions (Trentino-Alto Adige, Lombardy, Veneto and Friuli-Venezia Giulia) and sixty municipalities were involved (3517 km²). The increased spread of rabies could be due to different factors: a new wide front opened in Valtellina (Sondrio) where the Stelvio National Park is situated and where, in consequence, no surveillance had been enforced. Presumably the infection had been present for some time, and the disease had become apparent only during this period. Also the cyclic pattern of sylvatic rabies associated with the fox is likely to have come into play. Towards the end of the year two additional fronts were created, one in Valtellina and one in the municipality of Trieste at the Yugoslav boundary. During February and April, three foxes were found to be infected in the Cuneo Province. The cases could not be related to any of the preceding outbreaks. An exhaustive investigation commenced and only after about two years was it established that ERA vaccine virus had been responsible for the cases.

1982

Forty-six municipalities were involved for the first time in the Provinces of Bolzano, Belluno, Brescia, Sondrio, Trieste, Gorizia and Udine (2402 km²). The epidemic advanced, especially in Venosta Valley (Bolzano) and Valtellina (Sondrio); the disease was again reported in Belluno Province in four municipalities bordering on Udine Province.

1983

The epidemic of wildlife rabies was brought under control in the Friuli-Venezia Giulia region, whereas the incidence increased markedly, with a large initial wave, in the Alpine provinces of Lombardy and in Trentino. Fifty-two municipalities belonging to eight Provinces (Udine, Gorizia, Trento, Sondrio, Como, Bergamo, Brescia, Bolzano) became involved (1510 km²). The persistence of such a high incidence was due to the fact that these areas border on the Stelvio National Park, which acts as a reservoir of infected foxes.
1984

The disease advanced in the Alpine provinces of Lombardy and in Trentino, where strict epidemiological surveillance was enforced. Seventy-two municipalities of seven Provinces (Udine, Trento, Bergamo, Bolzano, Como, Sondrio, Aosta) became involved (2182 km²). In April, rabies appeared for the first time in Valle d’Aosta; it was probably introduced from Savoy (France) where outbreaks had been reported. At present, the eastern part of Bolzano Province, which was infected from 1977 to 1979, has been rabies-free for six years.

1985

The epidemic advanced in Trento Province involving areas densely inhabited by man (Adige Valley and Lake Garda). In those provinces where the disease is still endemic, mosaic-like foci are found.

RABIES PROPHYLAXIS IN ITALY

In view of the complexity of wildlife rabies, its prophylaxis is not feasible by following a single control policy. It is necessary to adopt all measures capable of reducing rabies incidence in domestic and wild animals, and reducing the risk of human infection. We think it proper to analyse the control measures taken in Italy, according to the division of animal species adopted by the World Health Organization (42).

Prophylaxis in man

Human vaccination is advocated for some categories at risk, using inactivated HCDS (Human Cell Diploid Strain) vaccine. People at risk are veterinarians, laboratory workers, gamewardens, park and forest rangers, hunters, farmers and first-aid physicians.

Prophylaxis in domestic animals

The control in carnivores is concerned with stray dog capture and, in some instances, shooting of stray and feral dogs.

Vaccination mainly concerns domestic animals living in infected and risk areas. Thus in 1985 (as in previous years) the vaccination of dogs and of cattle, sheep, goats and horses kept on pasture-lands and exposed to infection in Piedmont, Valle d’Aosta, Liguria, Lombardy, Veneto, Friuli-Venezia Giulia, and in the autonomous provinces of Trento and Bolzano, was made compulsory (Ministry of Health Ordinance of 24/5/1985). All the above-listed species are vaccinated with modified live ERA vaccine, manufactured by the Istituto Zooprofilatico Sperimentale of Perugia: one million doses, $ US 0.23/dose*. Also, according to the above law, the vaccination of dogs and other animals may be made compulsory if “justified epidemiological reasons” exist; such a compulsory vaccination may also include domestic carnivores transported by people who move from rabies-free zones to infected areas. The cost of this vaccination is calculated at about $ US 795,000 ($ 225,000 for the vaccine plus $ 570,000 for veterinarians).

* One $ US = 1500 Italian lire.
Prophylaxis in wild animals

In Italy, fox populations were thinned out in the Alpine areas. This reduction was also carried out in other rabies-free and risk-free Italian regions (e.g., Tuscany, Emilia-Romagna, Abruzzi and Molise). The thinning out of the fox population in Italy was done by shooting, which is regarded as an effective, specific method in our territories. To encourage the efficiency of this method, premiums were offered which varied from region to region (Table I). In addition, though in the absence of a uniform programme in the Alpine Provinces, there was good coordination by the local (provincial) administration, with assistance from gamewarden's of the provincial administration. The cost of such a control was estimated to be around $ US 216,000 (i.e. $ US 53 for each fox killed) during 1983 and around $ US 246,000 ($ US 54 for each fox killed) during 1984. We are also sure that strychnine-poisoned baits, although forbidden by the hunting legislation (law No. 968, 1977), were used in the Provinces of Belluno, Bolzano, Udine and Trento.

With regard to the vaccination of foxes in November 1984, a trial was started in Camonica Valley (Brescia) to immunize foxes orally with the use of strain SAD-B/19 Tübingen in the form of capsules inserted in chicken heads delivered as baits. The involved area included 45 municipalities encompassing about 700 km². In this area 7,500 baits were delivered by previously trained personnel under the supervision of the Istituto Zooprofilattico Sperimentale of Brescia. During January and February 1985, 70 foxes and other wild animals were shot in the vaccination area in order to check the efficiency and innocuity of the vaccination, and to assess whether the baits had been accepted, the animals had developed antibodies and the vaccinal virus could be reisolated from them. Unfortunately, the shooting programme scheduled to verify the effectiveness and innocuity of vaccination was not duly implemented, and this may jeopardize the success of the action. The cost of such a vaccination may be calculated at around $ US 17/vaccinated fox.

Now an experimental programme of oral vaccination of foxes, employing SAD-B/19, is also being started in Trento and Bolzano Provinces. 30,000 baits, composed of fish meal and pig fat, will be distributed in the following areas: \(a\) in Camonica Valley (Brescia), where vaccination had previously been carried out, comprising an area of 700 km²; \(b\) in Sabbia Valley (Trento, Brescia) and bordering zones of Lake Garda (Trento), comprising about 2,000 km²; \(c\) in three municipalities of Bolzano Province, bordering the infected areas of Trento Province.

Information and health education

A veterinary supplement of the “National Epidemiological Bulletin” of Italy, including a specific table showing infected municipalities, is published monthly. In addition, our Institute co-ordinates the transmission of quarterly data and the relevant commentaries to “Rabies Bulletin Europe”, issued by the WHO Collaborating Centre for Rabies Surveillance and Research at Tübingen.

There is little health education activity for the general public or at multidirectional level in major centres, such as individual Local Health Units and primary schools. There are, though, some exceptions such as an illustrated brochure published in Bolzano Province, and a film prepared by the Lombardy Region.
DISCUSSION AND CONCLUSIONS

At present, rabies is spreading in Italy in areas where human populations and settlements are very conspicuous, with a resultant hazard of human infection. However, the disease is still under control and confined to certain Alpine regions. Luckily, the infection has not involved the Po Valley where, due to the low fox density, the conditions are such as to prevent rabies from becoming endemic. There is still a risk that the disease could jump the Po Valley through an infected dog and/or fox carried by man, so reaching the Apennines where it may find conditions ideal for becoming endemic. Alternatively, rabies might gain access to the Apennines by way of that geographic area where the western Alps are contiguous with the Apennines although, at present, the disease appears to have stopped in Valle d’Aosta. It should be noted, however, that, in the Po Valley, the fox population density along rivers is higher than in the surrounding territories (30, 12). Such rivers could constitute a channel for rabies transmission in the Po Valley.

As far as man is concerned, we believe that health education in infected and risk areas is of primary importance in order to prevent human infection from non-carnivorous animal species, but without causing needless alarm. To this end, a decisive role could be played by the use of audiovisual systems and lectures in primary schools. However, despite wildlife rabies having been present in Europe for a number of years, it has been shown that the risk of human beings contracting the disease is extremely limited, and not comparable with the health hazards associated with urban rabies. Indeed, in all European countries where wildlife rabies is present, only eighteen cases (apart from the imported ones) were reported from 1977 up to the first six months of 1985, none of them in Italy. Prior to urban rabies eradication in 1973, 14 cases were reported annually in Italy (29).

In Italy, domestic animals are still being vaccinated with attenuated live vaccine (ERA strain) which, in the past, proved important in the control of rabies but which should, today, be replaced with inactivated virus vaccines that are equally effective but completely safe (27, 8). It would be desirable, therefore, to introduce the use of inactivated vaccines which several investigations, also carried out in Italy, have shown to be fairly effective and totally harmless (26, 5, 15, 32, 33). Inactivated virus vaccines should be employed both in the compulsory State prophylaxis and in the voluntary one, both in carnivores and other animal species. The problem is the high cost of inactivated virus vaccine production. In ruminants, the cost of vaccination could be reduced by the use of a combined rabies and foot and mouth disease vaccine. The State prophylaxis programme has not included the cat which, in our opinion, should also be compulsorily vaccinated with inactivated virus vaccine in infected and risk areas. The main drawback to the enforcement of such a prophylaxis would be the difficulty of capturing cats which live in rural regions.

Special attention should be paid to the problem of roaming, stray and feral dogs that are present in noticeably high densities in central-southern Italy (13). These animals could play a very important role should sylvatic rabies be introduced along the ridges of the Apennines. While feral dogs live in contact with other wild animals and may encourage the spread of rabies in wildlife, stray dogs represent a link between wild and domestic animals in that they are used to living with man and, hence, do not fear him and enter inhabited places. In addition, feral dogs present the genetic danger of cross-mating with the wolf. As a prophylactic measure, the capture and killing of stray and feral dogs seems to be advisable. In future, it would be desirable to have all domestic dogs tattooed in order to be able to immediately identify roaming individuals.
In the case of wild animals it would be proper, pending any direct prophylaxis, to make as accurate an estimate as possible of the population density of foxes as they are the reservoir of wildlife rabies. In Europe, investigations on density and behaviour of foxes have been carried out only in Holland, Denmark, the United Kingdom and Switzerland (22).

A very important factor in rabies prophylaxis is the control and fencing of rubbish dumps which, being feeding sites, represent a key element for the structure and size of the fox territory. With feeding sites increasing in number, the size of territories decreases, and the average number of the members of a group will become higher, with a resultant increased fox population density (23). Also, uncontrolled dumping areas may eventually constitute a link between the cycles of wildlife and urban rabies since they are a meeting place for foxes, stray and feral dogs, and cats.

We think it unnecessary to thin out fox populations in those regions of central and southern Italy which are situated several hundreds of km from the rabies epidemic. It should also be remembered that in such regions little or nothing is being done to control stray and feral dogs in connection with echinococcosis-hydatidosis which is prevalent in these areas. In addition, the Italian regions where the reduction of fox density was carried out have done little or nothing to limit the causes of abundant food availability which is responsible for high fox density. Fox culling campaigns, although under the supervision of the local administrations, were nearly always committed to hunting associations that almost always put them into effect during the spring-summer period (outside the free hunting season), whereas the best time for such an action would have been autumn-winter in order to curb the itinerant part of the fox population, which is the most important factor in encouraging the advance of rabies. It is apparent, therefore, that this policy is based upon hunters' interests rather than upon prophylaxis proper.

In the prophylaxis of rabies the possibility also exists of immunizing foxes by the oral route and, in consequence, of immunizing the reservoir species in Europe. However, it must be pointed out that fox immunization is only one particular, though attractive, aspect which has stimulated research and investigational work on wildlife rabies control for fifteen years. It is just because sylvatic rabies control cannot be accomplished through a unique approach, that the oral vaccination of foxes cannot, and should not, be an alternative to the previously discussed measures. Furthermore, such a vaccination should be carried out in readily controllable and naturally delimited areas with known wildlife densities (especially foxes) and a low human density. In Switzerland and Germany, methods of oral fox vaccination have been developed which entail the use of strains SAD-BHK/21 Berne and SAD-B/19 Tübingen, respectively (35, 37, 41). Neither strain has residual pathogenicity for the target species (the fox) or other wild and domestic animals (37, 40, 34, 18). In addition, they have shown a good efficacy and, if incorporated in such suitable baits as chicken heads, might be easily found and ingested by foxes.

A different approach is needed to the problem of safeguarding the wolf; in Italy this animal species consists of a population of about 200 individuals distributed over nine regions (Tuscany, Umbria, Lazio, Marche, Abruzzi and Molise, Campania, Basilicata, and Calabria) which, by virtue of the long geographical isolation, has developed special characteristics of adaptation to the Italian situation (14). This animal would be exposed to a serious risk if rabies were to reach the Apennines; its safeguard, therefore, could also depend upon the development of a suitable oral vaccine.
Up to the present time, all prophylactic actions devised to control sylvatic rabies have been generally implemented without any due allowance being made for the results of a cost/benefit analysis. For instance, the data available on fox culling interventions do not permit a calculation of either HIPD values or other indexes of relative abundance in territorial sizes smaller than a province for more than two years, whereas, in monitoring the disease, it is difficult to assess (with the exception of absolute values for infected animals) rabies incidence in the different geographic areas, and the changes that have occurred.

To conclude, we believe that the entire policy concerning the prophylaxis of rabies in Italy should be reviewed and revised by (a) restricting state vaccination to domestic animals only, in infected and risk provinces; (b) not presenting fox population thinning as an efficient measure for rabies control in areas other than infected and/or at risk; (c) acting on ecological factors responsible for the increase of fox population density; (d) financing surveillance, information and health education rather than the free distribution of vaccine to the farmers involved; (e) further extension of fox vaccination trials.

The cost/benefit figures of rabies control campaigns should be evaluated in wildlife populations. Greater national co-ordination is needed in the different actions being undertaken.

* * *


* * *

EPIDEMIOLOGÍA Y CONTROL DE LA RABIA EN LAS ZONAS ALPINAS. EL CASO DE ITALIA. — S. Prosperi, A. Giovannini y L. Paulucci de Calboli.

Resumen: Se presenta la situación epidemiológica de la rabia selvática en Italia, de 1977 a 1985, especialmente en base a gran cantidad de animales controlados y positivos, distribuidos según las distintas especies. Se pone especial énfasis en la propagación geográfica de la enfermedad, tal y como resulta de
una serie de mapas. Se examina asimismo el influjo de la biología de los animales salvajes (especialmente del zorro) en las características epidemiológicas de la rabia, muy especialmente en el contexto italiano. Se estima la difusión de los zorros en las regiones alpinas de Italia en base al número de zorros matados por km² en 1983 y 1984. Se contemplan las medidas de control aplicadas en Italia en función de sus resultados y de sus costos reales, y con miras a mejorar su planificación y su aplicación.


* * *

REFERENCES


