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Current status of fox rabies in Europe

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ABSTRACT

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There was a general decline in animal rabies in Europe in 1991 following the peak levels which occurred in 1989. This was ascribed, in France at least, to the normal decline in cases usually experienced following peak occurrence and also to oral immunization of foxes against rabies.

European countries in which rabies occurs may be infected by fox, insectivorous bat or dog rabies. This paper makes a general summary of the rabies situation in Europe in 1991 and presents data obtained in 1991 from 15 European countries using oral vaccination against fox rabies.

RABIES SITUATION IN EUROPE IN 1991

There are a number of animal reservoirs of rabies in Europe: red fox (*Vulpes vulpes*), polar fox (*Alopex lagopus*), dog and insectivorous bats (mainly *Eptesicus serotinus*). Some of the data presented here is derived from the *Rabies Bulletin Europe* published at the World Health Organization (WHO) Collaborating Centre in Tübingen, Germany.

In 1989 there had been a general increase in fox rabies cases in Europe (principally in France, Belgium and Germany) which was interpreted as being the consequence of two mild winters which favoured the survival of foxes and their prey, resulting in an increase in the fox population and the occurrence of rabies.

In 1991, 16 490 cases of rabies were reported in Europe, which was 22 % less than in 1990 (Table 1). However, this downward trend in cases was not evident in Austria, Poland, Romania and Switzerland. Such an overall decrease in incidence is to be expected after a period marked by a very high occurrence of rabies, but the most significant decreases were recorded in the countries where oral vaccination

TABLE 1 Animal rabies cases in Europe in 1991[a]

Country	No. of cases reported	Trend (%) since 1990
Austria	2 460	NS[b]
Belgium	29	– 75
Czechoslavakia	1 359	NS
France	2 165	– 27
Germany	3 602	– 35
Hungary	880	– 19
Italy	4	+ 100
Luxembourg	16	– 75
Netherlands (bat rabies cases)	12	– 46
Poland	2 287	+ 12
Romania	54	+ 10
Spain (African part)	8	NS
Switzerland and Liechtenstein	105	+ 105
Turkey (canine rabies principally)	427	– 27
USSR (canine rabies principally)	2 404	+ 35
Yugoslavia (canine rabies principally)	669	– 20

[a] Data extracted from *Rabies Bulletin Europe*
[b] NS = Not significant

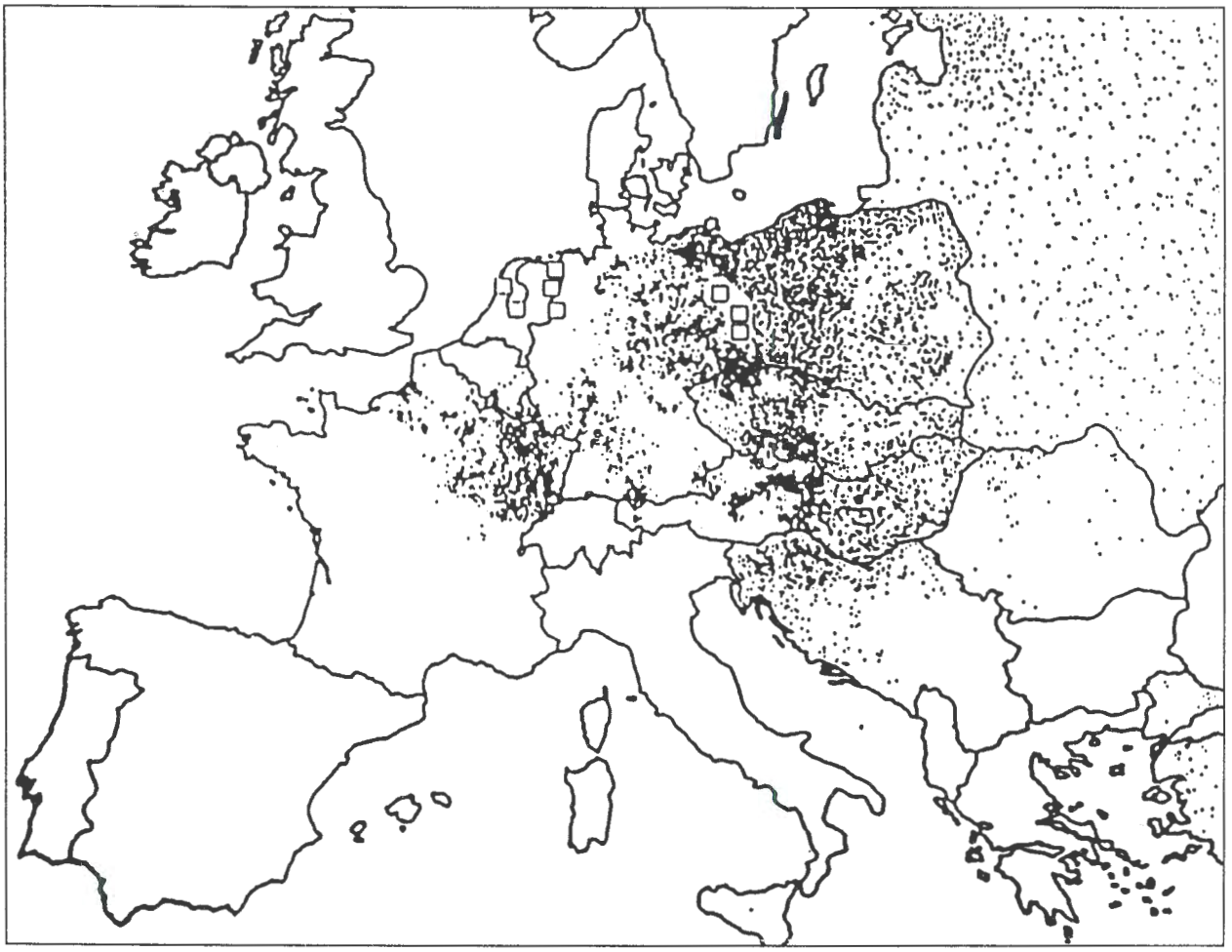

FIG. 1 Rabies distribution in Europe in 1991. Each point corresponds to a case of rabies in a terrestrial mammal. Bat rabies cases are indicated by squares. This map was edited from the quarterly maps published by WHO collaborating centre in Tübingen (FRG)

TABLE 2 Trend in rabies incidence between 1990 and 1991 in French départements vaccinated at least once during or before autumn 1990

Species	1990[a]	1991[a]	Trend (%)
Red foxes	515	123	– 80
Total wildlife cases	**524**	**129**	**– 80**
Dogs	5	2	–
Cats	9	3	–
Cattle	17	5	– 70
Sheep and goats	40	4	– 90
Total domestic animal cases	**73**	**15**	**– 79**
Total	**597**	**144**	**– 80**

[a] These data were collected in the départements of Ain, Cher, Eure, Nièvre, Rhône, Saône et Loire, Seine et Marne, Yvelines and Val d'Oise (total area 47 123 km^2)

campaigns had been undertaken. Switzerland was the exception to this trend. There, fox populations had increased following earlier oral immunization campaigns only to be followed by the re-introduction of rabies from a neighbouring country. Fifteen cases of bat rabies were recorded in Europe in 1991: 12 in the Netherlands and three in Germany. Most of these occurred in areas where no fox rabies is present. As was the case for rabies in terrestrial animals, fewer cases in bats were reported in 1991 than 1990 (22 cases) or 1987 (142 cases). The distribution of rabies cases in animals in Europe is shown in Fig. 1.

No human rabies was reported in 1991.

Influence of oral vaccination campaigns on fox rabies

Data from France show that country-wide oral vaccination campaigns induced a decrease in fox rabies

TABLE 3 Trend in rabies incidence between 1990 and 1991 in French départements never vaccinated prior to the autumn of 1990

Species	1990[a]	1991[a]	Trend (%)
Red foxes	313	333	+ 6
Total wildlife cases	**325**	**356**	**+ 10**
Dogs	11	12	+ 9
Cats	21	23	+ 10
Cattle	11	19	+ 73
Sheep and goats	27	67	+ 148
Total domestic animal cases	**77**	**130**	**+ 69**
Total	**402**	**486**	**+ 21**

[a] These data were collected in départements of Haute Marne, Bas Rhin, Haute Saône and Vosges (total area = 22 200 km^2)

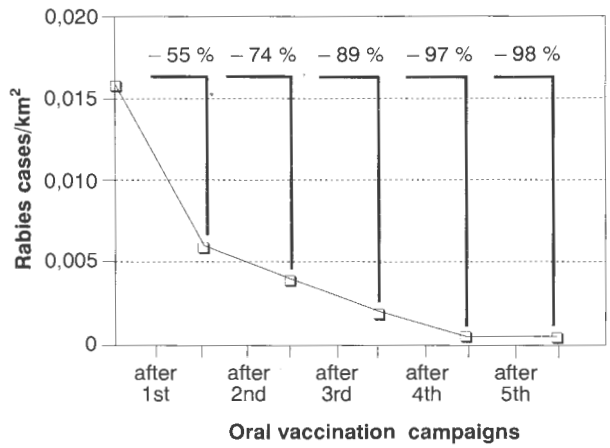

FIG. 2 Evolution of rabies case density in areas submitted to oral vaccination campaigns from 1989 to October 1991. Data are grouped by six month periods (November to next April and May to October)

as well as in other species. Table 2 summarizes the difference in incidence between 1990 and 1991 in départements (an administrative division of nearly 5 000 km^2) in which bait vaccine was distributed throughout the département at least once during or before autumn 1990, while Table 3 shows the trend in départements never vaccinated before autumn 1990.

The general trend between 1990 and 1991 was an increase of 21 % in unvaccinated départements while an 80 % decrease was experienced in vaccinated ones. It is furthermore probable that the better surveillance of fox rabies during oral immunization campaigns resulted in a higher proportion of rabies cases in these animals being reported in vaccinated départements than in unvaccinated départements.

In unvaccinated départements, the increase in rabies incidence was more marked in domestic than in wild animals. These départments have been infected with rabies for a long time and for this reason rabies in wildlife does not draw much attention and the presence of rabies is therefore better indicated by the presence of the disease in domestic animals.

Another way of estimating the efficiency of oral vaccine of foxes is to measure the number of rabies cases/km^2 of vaccinated area following oral immunization. Fig. 2 shows cumulative data collected between 1989 and October 1991. Before oral vaccination of foxes, rabies case density was 16/1 000 km^2. The occurrence of rabies was then measured during the 6 month periods including and following oral vaccination campaigns (i.e. from November to the next April and from May to October).

Where no rabies case were identified in an area following a vaccination campaign, this zone was not included in the calculations, so it may be assumed that the decrease in rabies cases was more marked following oral immunization than indicated by Fig. 2.

Control of foxes rabies in Europe

Prior to the meeting on Rabies Control in Europe, held in Nancy (France) in 1991, a questionnaire was sent to heads of national veterinary services of all European countries. Twenty-five countries provided answers to the questionnaire. The answers indicated that 16 made an effort to control fox numbers while 15 were using oral vaccination of foxes. Furthermore, the area covered by oral vaccination campaigns in Europe has increased steadily: 55 000 km^2 in 1988, 178 000 in 1990 and 269 000 in 1991.

Conclusions based on data derived from answers to the questionnaire are summarized below and details shown in Tables 4–14.

Status of oral vaccination of foxes

- Eleven of the responding countries which are using oral immunization still consider the measure experimental despite large areas being covered in some cases (Tables 5 and 7). Financial support of these operations is both governmental and regional and the participation of the EEC was indicated by three countries (Table 5). With the exception of Czechoslovakia, state agents distribute or participate to the distribution of baits in all European countries.
- Bait vaccines are distributed by hand on the ground exclusively by four countries, three others use only aerial distribution while three countries are using both methods. Among aerial distribution techniques, helicopters are most frequently used (Table 6).
- The density of baits distributed in treated areas is between 13 and 20/km^2 but is not always homogeneous; in six countries the density of distributed baits varies with the topography (Table 6). Two

TABLE 4 Control measures used against rabies in wildlife in Europe: 1991

Country	Fox					Other wild species			
	Offensive measures	Culling	Vaccination		Bounty	Species	Culling	Vaccination	Bounty
Germany	Yes	S	Yes		No				
United Kingdom	No			No	No				No
Austria	Yes	S, G, P T	Yes	Yes	No				
Belgium	Yes	S	Yes	Yes	No				No
Cyprus	Yes	S, P	No	No	No				No
Denmark			Yes	No	No				No
Spain	No			No					
Finland	Yes	S, T	Yes	No	Yes	Racoon dogs	S, T	Yes	No
France	Yes	S, T	Yes	No	No				No
Greece	Yes	S, T	Yes						
Netherlands	Yes	S	Yes	Yes	No				No
Hungary	Yes	S		Yes	No				
Ireland	No			No	No				No
Italy	Yes	S	Yes	Yes	No				No
Luxembourg	Yes	S	Yes		No				
Norway	No				No				
Poland	No			No	No				No
Portugal	No								
Romania	No								
Sweden	Yes	S, T	Yes	No	No				
Switzerland	Yes		Yes	No	No				No
Czechoslovakia	Yes	S	Yes	Yes	No				No
Turkey									
USSR	Yes	S	Yes	Yes					
Yugoslavia	Yes	S, T	Yes	Yes	No				

S = shooting; P = poisoning; T = trapping; G = gassing

TABLE 5 Financial support of oral vaccination campaigns in Europe: 1991

Country	Experimental oral vaccination	Main financial support	Other sources[a]
Germany	Yes	R/L	
United Kingdom	No		
Austria	Yes	R	
Belgium	Yes	C/R	
Cyprus	No		
Denmark	No		
Finland	Yes	C	
France	Yes	C/R	EEC
Netherlands	Yes	C	EEC
Hungary	No		
Italy	Yes	R	
Luxembourg	Yes	C	
Poland	No		
Portugal	No		
Romania	No		
Sweden	No	C	
Switzerland	Yes	C/R	
Czechoslovakia	Yes	C	EEC
Yugoslavia	Yes		UEEB[b]

C = central origin; R = regional origin; L = local origin

[a] The EEC reimburses up to 50% of money spent on oral vaccination of foxes in some circumstances

[b] Union Europ. Elev. de Bétail

campaigns are conducted each year, one in spring and the other in autumn (Table 6).

- Four vaccine viruses are incorporated into baits used in Europe. Three are attenuated strains (SAD Bern, SAD B19 and SAG1) and the fourth is a vaccinia/rabies-glycoprotein recombinant (VRG strain) (Table 8).
- Assessment of the efficiency of oral vaccination of foxes is conducted both by surveys of rabies cases in treated areas (11 countries) and by examination of specially sampled foxes in these areas (0,01 to 0,75 animals/km^2) in ten countries (Table 9).
- Bait intake is measured by the deposition in bone and teeth of tetracyclin used as a biomarker in the baits. The detection of the marker is performed by uv fluorescence of tooth sections (three countries), sections of lower jaw (eight countries) or femur (two countries) (Table 11).
- Seroconversion is measured in ten countries by serum/virus neutralization tests on the sera of sampled animals, while an ELISA technique is used by one country (Table 9).
- The possibility of the vaccine virus inducing rabies in foxes or other wildlife is tested by the use of monoclonal antibodies able to distinguish the vaccine from street strains (Table 9).

TABLE 6 Distribution of bait vaccines in Europe: 1991

Country	Distribution		Distributing teams	No. of baits/km^2	Season	Untreated areas
	On foot	By air				
Germany	F	P, H	O	15–20	Spring/autumn	
Austria	F		V, O	16	Spring/autumn	Cities, water, mountains
Belgium	–	P, H	V, O	15	Spring/autumn	
Finland	F	P	V, O	15 on foot, 20 by air	Spring/autumn	Only border regions vaccinated
France	–	H	O	13	Spring/autumn	Residential areas
Netherlands	F		V, O	16	Spring/autumn	Cities
Italy	F	+	V, O	5–20	Spring/autumn	
Luxembourg	–	H	O	20	Spring/autumn	
Switzerland	F		V, O	15	Spring/autumn	Alt. > 2000 m
Czechoslovakia	F	H	V	15		
Yugoslavia	F		V, O	16	Spring/autumn	

F = foot; P = aeroplane; H = helicopter; V = volunteers; O = official agents; + = unknown

TABLE 7 Areas over which bait vaccines against rabies in foxes were distributed in Europe: 1988–1990

Country	Treated area (km^2)		
	1988	1989	1990
Germany	18 000	94 000	93 000
Austria	9 800	16 000	25 000
Belgium	9 500	10 000	10 000
Finland	2 825	9 700	2 000
France	4 626	28 305	106 518
Netherlands	260	260	260
Italy	(1987) 5 392	2 370	
Luxembourg	2 587	2 587	2 587
Switzerland	7 252	7 822	10 334
Czechoslovakia		3 307	14 520
Yugoslavia	580	3 500	4 500

TABLE 8 Vaccine strains incorporated into oral baits for immunization of foxes in Europe

Country	Usage (% per annum)			
	SAD B19	SAG1	VRG	SAD Bern
Germany	100			
Austria	100	0	0	0
Belgium (1991)			100	
Finland	100			
France (1990)	42	19	39	0,9
Netherlands	100	0	0	0
Italy	100			
Luxembourg	100	0	0	0
Switzerland (1990)				100
Switzerland (1991)		100		
Czechoslovakia	100			
Yugoslavia	100			

TABLE 9 Details of methods employed by European countries in the monitoring of oral vaccination campaigns

Country	No. of foxes collected/km^2	No. of laboratories involved	Tetracycline detection		Sero-logical technique	Other serology	Differentiation between rabies virus and vaccine strains	
			In teeth	In bones			Tested	Technique
Germany	0,025			Lower jaw	FFI[a]		Yes	Mabs
Austria		1		Lower jaw	FFI		No	
Belgium	0,040	1		Lower jaw	FFI	Vaccinia	No[b]	
Finland	0,008	1	Yes	Lower jaw	FFI		Yes	Mabs
France	0,011	1	Yes	Lower jaw	FFI		Yes	Mabs
Netherlands	0,750	1		Femur	FFI		No	
Italy	0,100	3		Lower jaw	FFI		Yes	Mabs
Luxembourg	0,100	1	Yes		FFI		No	
Switzerland	0,100	1	No	Femur	ELISA		Yes	Mabs
Czechoslovakia	0,900	1	No	Lower jaw	FFI		Yes	Mabs
Yugoslavia	2,000	1		Lower jaw	FFI		No	

[a] FFI = flourescent focus inhibition test

[b] The use of VRG vaccine eliminates this risk

TABLE 10 Studies conducted in parallel with oral vaccination control

Country	On foxes	On other species		
		Yes/No	Tetracycline	Other subjects
Germany	Population dynamics	No		
Austria	No	No		
Belgium	Population dynamics & echinococcosis	Yes	Yes	
Finland	No	Yes		Biology of raccoon dog, game density
France	Population dynamics	Yes	Yes	
Netherlands	No	Yes	Yes	
Luxembourg	Echinococcosis & trichinellosis	No		
Switzerland	Population dynamics	Yes	Yes	Population dynamics
Czechoslovakia	Bait intake at day 4, 8 and 14	Yes	Yes	
Yugoslavia	No	Yes	Yes	Wild boar

TABLE 11 Results obtained during oral vaccination campaigns in various European countries

Country	Vaccinated species	Campaign no.	Bait intake (%)[a]			Seroconversion (%)[b]			Vaccinal strain	Remarks
			Min.	Ave.	Max.	Min.	Ave.	Max.		
Germany	Fox		60	80	90	50	70	80		
Austria	Fox	1	55		60	47		51		3–5 % of TET – seroconvert, 80–85 % of TET + seroconvert
	Fox	2	70		80	59		67		3–5 % of TET – seroconvert, 80–85 % of TET + seroconvert
	Fox	3	70		80	59		67		3–5 % of TET – seroconvert, 80–85 % of TET + seroconvert
Belgium	Fox	1		53,5					SAD B19	Distributed on foot
	Fox	2		41					SAD B19	Distributed by air
	Fox	3		73					VRG	6/7 seroconvert
	Adult fox	4		86					VRG	n = 50
	Young fox	4		25					VRG	n = 20
Finland	Racoon dog	1		75						
	Racoon dog	2		50						
	Fox	1					72			
	Fox	2					38			
	Fox	3					63			
	Fox	4					75			
France	Fox	1		44			40			
	Fox	2		62			60			
	Fox	3		70			65			
	Fox	4		80			75			
Netherlands	Fox	1		46						
	Fox	2		84						
	Fox	3		67			40			
	Fox	4		92			77			
Italy	Fox	1	4	43	29	4	44	24	SAD	
	Fox	2	5	18	8	4	15	7	SAD	
Luxembourg	Fox	5	63	68	75	60	72	80	SAD B19	
Switzerland	Fox		45	60	80	40	50	60		Values depend on age, season of sampling and of baiting
Czechoslovakia	Fox	1		56			50			
	Fox	2		53			50			
	Fox	3		79,5			42			
Yugoslavia	Fox	1	35	54	75	30		60		

[a] Determined by tetracycline deposition in bone or teeth (see Table 9)

[b] Presence of antibodies at levels considered indicative of protection

TABLE 12 Cost of oral vaccine campaigns, future of these operations

Country	Cost/km^2 (in ECU)			Future of oral vaccination	Reason
	Vaccine	Baiting	Control		
Germany	15			Continue	
Austria	14,88			Continue	
Belgium	15,50	1,70		Continue	
Denmark				Continue	
Finland	70 on foot, 90 by air[a]	50 on foot, 12 by air[a]		Continue	On the border
France	14,24	8,49	1,76	Continue	
Netherlands	15,50	13,00 with control		Stop	No more rabies
Italy				Continue	
Luxembourg	9,5	18,3		Continue	
Sweden				Continue	
Switzerland	14,5 with control	8,9		Continue	
Czechoslovakia	500[a]	20[a]	150[a]	Continue	
Yugoslavia	15,55			Continue	

[a] In local currency

TABLE 13 Changes in fox densities following oral vaccination campaigns against rabies in foxes

Country	Increase of fox density	Origin of data	Increase is considered as serious	Reason
Germany	Yes	Field observation	No	A new level has to be reached
Austria	Yes	Field observation	Yes	Rabies control in the free area
Belgium	Yes	Field observation	Yes	Echinococcosis
Finland	No	Field observation		
France	Yes	Field observation	No	No scientific evidence
Netherlands	Yes	Field observation	No	Also observed in rabies free area
Italy	Yes	Field observation	Yes	Risk of other disease (echinococcosis)
Luxembourg	Yes	Field observation	Yes	Return of rabies; echinococcosis
Switzerland	Yes	Field observation	Yes	Return of rabies; echinococcosis; mange
Czechoslovakia	No	Field observation		
Yugoslavia	Yes	Field observation	No	

The influence of oral vaccination of foxes on non target species is followed by six countries (Table 10).

Results of oral vaccination campaigns

The overall results of oral vaccination of foxes against rabies can be summarized as follows:

- After three campaigns in France, 80 % of foxes in the vaccination zones have consumed at least one bait and more than 70 % have seroconverted.
- Among the 13 European countries that have answered this question, 12 intend to continue oral vaccination of foxes; the 13th will discontinue the exercise because fox rabies no longer occurs in that country (Table 12).
- On the basis of field observations, nine countries indicated that the eradication of rabies or a lowering in the incidence of the disease will result in an increase in fox numbers (which is also noted in rabies free areas). Five of them consider that this may increase the risk of echinococcosis and also pose the problem that a high density of susceptible foxes could result in explosive spread should the infection be re-introduced (Table 13).

TABLE 14 Exchange of data on oral vaccination

Country	Type of exchange
Germany	Official
Austria	Unofficial
Belgium	Official and unofficial
Finland	Unofficial
France	Official and unofficial
Netherlands	Official and unofficial
Italy	Official
Luxembourg	Official
Sweden	Official and unofficial
Switzerland	Unofficial
Czechoslovakia	Official
Yugoslavia	Official