

# Oral immunization of foxes against rabies: practical experiences of a field trial in the Federal Republic of Germany

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*The development of and the logistics used in campaigns for the oral immunization of foxes against rabies in the Federal Republic of Germany are described. The "Bavarian Model", which is outlined in detail, shows how local hunters were recruited for bait distribution and control measures at practically no cost. Over 10 million baits have been distributed in this way by hundreds of thousands of hunters in the Federal Republic of Germany as well as in the other European countries that participated in this large-scale field trial.*

*As a result of the trial, rabies has been reduced or even eradicated in large parts of the Federal Republic of Germany.*

Described are the logistics used in campaigns for the oral immunization of foxes against rabies. These logistics, which have become known as the "Bavarian Model" were developed during the initial stages of a field trial in the Federal Republic of Germany. Use was made primarily of the services of volunteer hunters to distribute baits according to map coordinates, to follow bait uptake, and to provide foxes for control purposes (determination of seroconversion rates). The logistics have subsequently been applied in other similar immunization campaigns, and today are used by many European countries.

## History of the field trial

In central Europe, the incidence of sylvatic rabies has steadily increased since the 1950s, with the red fox (*Vulpes vulpes*) being the principal vector (2). The goal of effective control measures has therefore been to decrease the frequency of infection by reducing the fox population or to interrupt the chain of infection. The establishment of natural immunity does not apply, since rabies leaves a fully susceptible surviving population. Experiments using increased hunting measures to decrease the number of foxes have been unsuccessful, and the widespread gassing of fox dens

was discontinued in Bavaria in the middle of the 1970s, principally for humane reasons.

In 1983 the WHO Expert Committee on Rabies recommended that, as a follow-up to large-scale field trials involving oral immunization of wild foxes against rabies that started in Switzerland in 1978 and in the Federal Republic of Germany in 1983, similar field trials be initiated in other countries, particularly under geographical conditions that differ from those that prevail in the Swiss Alps (5).

For distribution in nature the oral vaccine for use in these trials has to satisfy the following criteria (3):

- highly immunogenic by oral application for the target species (fox);
- safe for domestic and wild animals;
- genetically stable;
- able to be differentiated from wild (street) strains; and
- stable for a considerable length of time under various temperature conditions.

The WHO Collaborating Centre for Rabies Surveillance at the Federal Research Centre for Virus Diseases of Animals, Tübingen, has developed a vaccine that meets the above requirements. This vaccine, SAD B19 (SAD=Street Alabama Dufferin) is a variant of the SAD rabies strain with defined properties. The Collaborating Centre has produced the SAD vaccine for the present field trial "Oral Immunization of Foxes in Nature against Rabies" (4), which began in 1983 in the following *Länder* (states): Bavaria, Hesse, and Baden-Württemberg.

In the popular press the impression has been created that the vaccine is swallowed by foxes in an

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analogous way to human oral poliovaccine. This is, however, not correct since the foxes bite into the vaccine capsule, thereby bringing the rabies virus into contact with the mucous membranes of the mouth and throat.

The goals of the field trial can be essentially reduced to providing answers to the following questions:

- Do foxes take uniformly placed baits, and what portion of the fox population can be reached by oral immunization?
- Is the method effective as a rabies control measure?

## The Bavarian Model

Permission for the experimental use of the SAD B19 vaccine was granted by the Bavarian Ministry of the Interior, which is responsible for veterinary aspects in this *Land*. The trial in Bavaria has been financed by funds provided by the Ministry of the Interior from the "Animal Disease Control" budget. In planning the experiment it was assumed that the costs would be DM 30–35 pro km<sup>2</sup> (US\$ 12.3–14.4 at the exchange rate that applied in March 1983).

The Bavarian veterinary authorities were faced with the challenge of creating a model for the organization of the field trial. From the beginning it was clear that a successful execution of the trial necessitated close cooperation between scientists, veterinary authorities, and hunters. In similar trials in Switzerland, in addition to the scientists and veterinary authorities in charge of coordinating the campaigns for oral immunization of foxes, various professional and nonprofessional groups (game wardens, auxiliary game wardens, police and hunters) are involved in preparing and distributing the baits. The auxiliary game wardens and hunters are volunteers. For example, in the Canton of Bern in 1981 hunters represented 26% of personnel involved in bait placement; in the Canton of Zug in spring 1982 they represented 65% of the total and received a per diem of SF 35 (US\$ 18.6 at the exchange rate that applied in March 1982) and in the Canton of Aargau in autumn 1983 the hunters participated without financial compensation. At the beginning of the trial the Bavarian authorities therefore decided that only owners, tenants, professional hunters, or forestry officials would distribute the baits in their own preserves. This raised the question of how to induce hunters to cooperate voluntarily in the trial.

Most of the Federal Republic of Germany is divided into small hunting preserves (*Jagdreviere*), which range in area from 0.7 km<sup>2</sup> to over 30 km<sup>2</sup>.

Each hunting preserve is owned or rented by individuals or groups.

The authorities most closely associated with hunters are the district (*Kreis*) officials who deal with the daily interests of the hunters, e.g., determining hunting quotas, etc. Such officials together with the district veterinary authorities were therefore the ideal means of liaising with individual hunters. This was important, since the organization of bait placement is carried out at the district level. The willingness of hunters to cooperate was increased by providing them with detailed information on the goals and execution of the trial. Through their participation, the public image of the hunters was also improved.

### Organization and execution of the trial

Approximately 3–4 months before the planned date for bait placement, a meeting of the authorities involved is held to draw up an exact plan for the execution of the campaign. This long advance period is chosen deliberately in order to give the district authorities sufficient time to make the necessary preparations. Such meetings are attended by officials from the following bodies:

- the WHO Collaborating Centre for Rabies Surveillance and Research, Tübingen;
- the Bavarian Ministry of the Interior;
- the State Veterinary Diagnostic Laboratory of Southern Bavaria, Oberschleissheim (the diagnostic laboratory for rabies in Bavaria);
- the Bavarian provincial government (*Landesregierung*), represented by the provincial veterinary authorities; and
- the veterinary and district officials from the districts involved.

For the organization and practical execution of the immunization campaign, the points outlined below are taken into consideration.

● **Immunization area.** The location and size of the immunization areas are determined according to criteria such as the incidence of rabies and geographical considerations. New vaccination areas should always have borders with areas already involved in the trial, since it is desirable to steadily enlarge contiguous immunization areas.

● **Baits.** The results of previous immunization campaigns indicate that a uniform placement of 15 baits per km<sup>2</sup> is sufficient, whereby the emphasis is on uniformity. At the beginning of the field trial in 1983, chicken heads were the only baits available. This bait had to be prepared manually, i.e., a vaccine capsule was placed in each bait, which was then injected with

150 mg of tetracycline as a marker. It soon became clear, however, that, although chicken heads were effective (rate of uptake, 75%; rate of seroconversion, 58%), the time and effort involved in preparing them limited any increase in the size of the immunization campaigns. In 1984, the WHO Collaborating Centre for Rabies Surveillance and Research, Tübingen, therefore, developed a bait that could be mass-produced (the "Tübingen fox bait"). Following successful trials in the field, this bait, which consists of a vaccine capsule embedded in a mixture of fish meal and fat (bait dimensions: 4 cm × 4 cm × 1.5 cm) has been used exclusively since autumn 1985. The Tübingen fox bait has proved its superiority not only because it can be mass-produced but also because it results in a greater rate of seroconversion (74%), while its rate of uptake (73%) is comparable to that of the chicken heads.

The Tübingen fox baits are packed in plastic bags containing 20 baits and are delivered in cartons of 800 baits. Currently, each bait costs about DM 1.70 (US\$ 1.00). The number of baits required is determined by the district officials, depending on the area of the hunting preserves to be covered, and within 14 days of the above-mentioned meeting to organize the campaign they order the appropriate number from the Collaborating Centre.

The Bavarian government also organizes the storage of baits (25 000 baits per m<sup>3</sup>) at -20 °C in central depots within the immunization area. The baits are delivered to the storage depots 1-3 weeks before the date set for placement and are collected by the district officials either on the day or the day before the actual placement. Experience has shown that earlier dates of collection can lead to problems associated with non-uniform interim storage conditions. The baits are distributed at the storage depot under the supervision of the responsible veterinary authority, while their distribution to the hunters is carried out at the district level.

● **Date of bait placement.** In those areas where rabies is continually present according to the patterns described by Jackson & Schneider (1), immunization campaigns have to be carried out at least twice at half-yearly intervals in order to eliminate the disease, e.g., the first campaign in spring (end of April or beginning of May) and the second in autumn (first half of October). In the autumn campaign the young foxes are reached that were not able to take the baits during the spring campaign. Further campaigns are necessary during the following year. In Alpine regions, it may be expedient to vaccinate later in spring and earlier in autumn.

At the campaign planning meeting, the exact date of bait placement is determined (all baits are

placed on the same date). The placing of baits at the weekend has proved to be advantageous because the hunters who perform this task as volunteers are not available at other times.

● **Organization of the bait placement.** As mentioned above, bait placement in Bavaria is carried out by hunters in their own preserves. This is the first time that mass mobilization of volunteers has been used in an experimental trial to control an animal disease. It has proved advisable to use teams consisting of at least two persons, with each person placing an average of 40 baits. This can be easily carried out in a day.

In Hesse, bait placement was initially carried out mainly by forestry officials in the course of their normal duties, whereby each team placed up to 400 baits. This number is, however, too large to ensure uniform placement.

One principle of the Bavarian Model is therefore "Many persons place few baits". Before baits are placed, the sites are marked on a map by the placement team. The maps (scale 1:5000 to 1:25 000) are procured by district officials, who also indicate on them the borders of the preserves. The marking of the sites on the maps prior to the placement operation is important in order to achieve the desired uniform distribution of baits, and experienced hunters have reported that without the premarked maps they would not have been able to place the baits uniformly.

One bait is placed at each site marked on the map. The bait is then covered with grass or leaves in order to hide and shade it. The placement teams wear plastic gloves provided by the veterinary officials to protect the bait against human scent.

In order to inform the general public about the bait placement activities, red plastic signs are erected bearing the caption "Attention, rabies immunization area" and giving also a short explanation about the field trial together with the notice that dogs and cats should not be allowed to run free. These signs, which are supplied by the district officials, are placed by the teams at the entrances to the immunization areas (at least five per preserve), especially at car parks.

● **Control preserves.** In order to determine the rate at which baits are taken up by animals, specially designated control preserves have been established (1-3 per district). In these preserves the bait placement teams check the baiting sites on days 4, 8 and 14 following placement and record the number of baits taken. In the course of their rounds, the hunters also look out for animal signs and tracks and examine any vaccine capsules that are found for teeth marks

in order to identify what kind of animal took the bait. Not only foxes but also wild boars, martens, badgers, dogs, and cats are attracted by the baits.

The prerequisite for the success of these checks is the precise marking of the bait placement site. Good results have been obtained using numbered wooden stakes, whereby the bait is placed directly next to the stake. If, however, the distance of the bait from the stake is too large it is difficult to find and this could lead to an incorrect estimate of the rate of baits taken.

The hunters responsible for the control preserves are each given an instruction leaflet by the district authorities together with forms on which to make a protocol of the bait uptake as well as observations.

● **Follow-up examinations.** In order to evaluate the field trial, precise information is required on bait uptake and seroconversion rates. These can only be obtained by examining foxes sent in by the hunters. Therefore, for a period of 3–4 months following bait placement a predetermined number of foxes have to be received by the veterinary diagnostic laboratory. As a general rule, significant conclusions can be drawn when one fox per 10 km<sup>2</sup> is examined from an immunization area of up to 1000 km<sup>2</sup> and one fox per 40 km<sup>2</sup> from larger areas. To allow seroconversion to take place, at least 4 weeks should be allowed to elapse after bait placement before beginning to collect foxes.

The fox cadavers are sent by the hunters to the veterinary diagnostic laboratory, which provides the plastic sacks and forms for shipment. The cadavers must be intact with pelt. Those without pelts dry out and, therefore, it is difficult if not impossible to obtain blood samples from the chest cavities. Each fox cadaver received is first examined for rabies by fluorescence microscopy. Should a fox be rabies positive, monoclonal antibodies provided by the WHO Collaborating Centre for Rabies Surveillance and Research are used to determine whether street virus or vaccine virus is involved.

The rate of bait uptake is determined by fluorescence microscopy of thin slices of bone for deposits of chlortetracycline. For this purpose, sections of the mandible are taken as well as of the canine teeth.

It is important to induce the hunters to shoot a sufficient number of foxes and send their cadavers with intact pelts to the veterinary diagnostic laboratory. To rely on voluntary collaboration for this appeared inadvisable, and it was therefore decided to pay DM 50.00 (US\$ 20.6 at the exchange rate that applied in March 1983) for each control fox received with pelt. To date, the quotas for the individual districts have usually been reached, although

during the summer months adult foxes are obtained less frequently.

● **Public information.** About 8 days before bait placement, the Bavarian government and the Ministry for the Interior distribute a press release which briefly describes the planned immunization campaign. The local press as well as radio and television stations are also informed by the district veterinary office. At the same time, local doctors, veterinarians, and schools receive leaflets from veterinary and district officials. The leaflets distributed to schools specifically mention that children should not pick up any baits they find since this would reduce the success of the trial.

● **Information for the hunters.** Experience has shown that it is beneficial to hold meetings with the hunters, at least in those districts where the immunization campaign has only recently been established. Such meetings, which are organized by district officials, are held in the evening about 3 weeks before bait placement to provide participants with the following information:

- a short summary of the previous rabies immunization campaigns in Bavaria;
- the scientific background of the trial and the most recent results;
- practical hints about sending in the control foxes; and
- the technical aspects of the trial.

After each of these well-attended meetings a lively discussion usually occurs. From the many questions that are asked it is clear that these meetings are extremely important for a successful immunization campaign. The presence of all the participating authorities at the meeting impresses upon the hunters the importance attached to the field trials. Therefore, in spite of the time and effort necessary to organize them, the policy of holding these meetings will continue.

Table 1 shows the results of the previous rabies immunization campaigns in Bavaria.

The influence of oral immunization on the development of rabies in Bavaria can be seen from Fig. 1, which shows the density of animal cases of rabies per 100 km<sup>2</sup> in immunized and non-immunized areas from 1975 to 1987. The total area of immunized areas was 25 775 km<sup>2</sup> and of the non-immunized, 44 771 km<sup>2</sup>. A steady decline in the density of rabies has occurred in the immunized areas, whereas in the non-immunized areas it has remained almost unaltered since 1985.

Table 1: Results of the campaigns for the oral immunization of foxes against rabies in Bavaria, 1983-87

Immunization campaign	Approximate area covered (km <sup>2</sup> )	No. of baits placed <sup>a</sup>	Bait uptake (%)	Seroconversion (%)
<b>1983</b>				
Spring	450	7000 (C)	78	74
Autumn	1500	20 000 (C)	76	38
<b>1984</b>				
Spring	2000	31 000 (C)	71	76
May	500	7500 (T) <sup>b</sup>		
Autumn	3600	55 000 (C + T)	72	51
<b>1985</b>				
Spring	4050	61 000 (C + T)	76	80
Autumn	5600	85 000(T)	76	80
<b>1986</b>				
Spring	16 000	240 000 (T)	80	85
Autumn	13 000	195 000 (T)	77	77
<b>1987</b>				
Spring	22 000	320 000 (T)	85	80
Autumn	37 000	555 000 (T)	81	73

<sup>a</sup> C = chicken head baits; T = Tübingen fox baits.

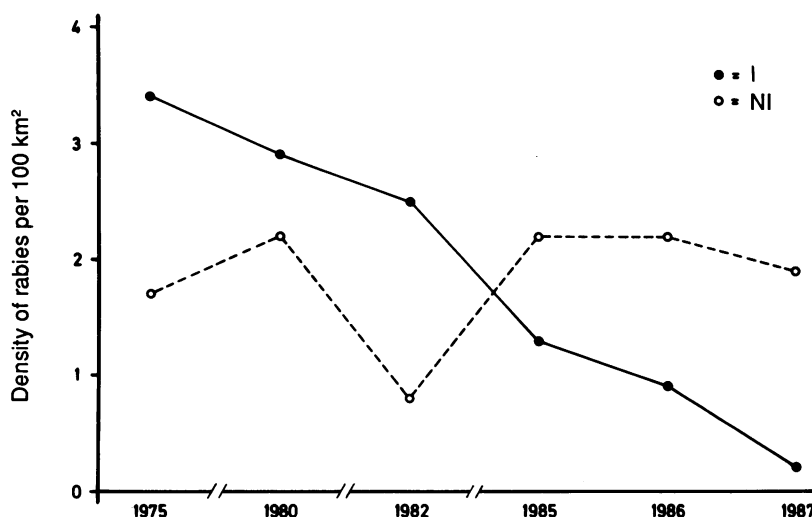
<sup>b</sup> Pilot project.

## Conclusions

The strategy of uniformly placing the baits reaches the majority of the fox population in the immunization areas. The rate of bait uptake, as measured by detection of chlortetracycline in thin slices of bone, is, on average, 73%. Seroconversion rates are 74%.

In every immunization area, a measurable decline in the incidence of rabies has been observed. In Bavaria, after an average of three consecutive immunization campaigns, approximately 25 000 km<sup>2</sup> of preserves are free of rabies. This includes areas in which over the past 15-20 years a consistently high frequency of rabies has been recorded, despite con-

Fig. 1. Plot showing the density of rabies in immunized (I) and non-immunized (NI) hunting preserves in Bavaria, 1975-87. I = 25 775 km<sup>2</sup>; NI = 44 771 km<sup>2</sup>.



ventional control measures. It is probable that these areas will not have to be revaccinated in the course of the present field trial.

On the basis of the results we have obtained so far, it would, however, be premature to end the field trial and to declare that the oral immunization approach should be adopted as the official rabies control procedure in the Federal Republic of Germany. Before this can be done, the following issues require to be addressed:

- development of strategies for areas with low or sporadic rabies frequencies;
- criteria for declaration of rabies-free areas;
- determination of the efficiency of ring or spot immunizations;
- determination of the efficiency of aerial baiting techniques in border areas; and
- determination of the minimal depth of preventive immunization cordons.

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## Résumé

### Vaccination antirabique des renards par voie orale: l'expérience pratique d'un essai sur le terrain en République fédérale d'Allemagne

L'article décrit le développement et la logistique des campagnes de vaccination antirabique des renards par voie orale en République fédérale d'Allemagne. Le "modèle bavarois" de ces campagnes, qui est ici présenté en détail, montre comment on a recruté des chasseurs locaux pour poser les appâts et les contrôler, à un coût pratiquement nul. Chaque chasseur pose au maximum 40 à 60 appâts. Plus de 10 millions d'appâts ont ainsi été posés de cette façon par des centaines de milliers de chasseurs en République fédérale d'Allemagne comme dans un grand nombre d'autres pays d'Europe. Le succès des campagnes de vaccination dépend en grande par-

tie de la participation des chasseurs bénévoles, dont on peut stimuler l'intérêt par des réunions d'information sur les buts et les perspectives de l'opération et les résultats des campagnes précédentes.

Il importe que les appâts soient posés régulièrement pour pouvoir atteindre la plus grande partie de la population vulpine de la zone concernée. Le taux d'absorption des appâts, mesuré par détection de chlortétracycline dans des coupes minces d'os prélevés sur les cadavres de renards, est en moyenne de 73%. Les taux de séroconversion sont de 74%.

Dans chaque zone soumise à la vaccination, on a observé un recul mesurable de l'incidence de la rage, et en Bavière, après en moyenne trois campagnes de vaccination successives, quelque 25 000 km<sup>2</sup> de réserves de chasse sont désormais indemnes de rage.

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