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COST-BENEFIT ANALYSIS OF THE ORAL IMMUNIZATION STRATEGY FOR THE CONTROL OF RABIES IN FOX POPULATIONS

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Les résultats d'une étude de deux stratégies d'éradication de la rage des renards différentes sont présentés : Ces deux programmes de lutte ont été conduits dans deux Etats différents de la République Fédérale Allemande entre 1986 et 1996.

Cette analyse s'est donné comme objectif de répondre à trois questions :

1. *Est-ce que les coûts globaux des différentes stratégies sont différents quand tous les coûts sont normalisés en Deutsch Mark par appât ?*
2. *Est-ce que les résultats exprimés par le pourcentage de zone couverte multiplié par le nombre d'appâts au km² sont différents en fonction des différentes stratégies ou vaccination orale ?*
3. *Y-a-t-il une relation entre les coûts cumulés par an et le nombre de cas de rage observés par an ?*

La réponse à ces questions a été obtenue par l'analyse des réponses à un questionnaire adressé aux responsables vétérinaires des laboratoires des deux Etats concernés.

L'analyse montre les points suivants :

1. *Les coûts normalisés par la mise en oeuvre des deux stratégies ne sont pas différents.*
2. *Les résultats sont différents entre les deux Etats.*
3. *Nous avons trouvé une relation entre les coûts cumulés par an et le nombre de cas de rage par an qui a pu être modélisée en utilisant une fonction exponentielle f(x) = a exp (-nx). Le paramètre n décrit le taux de décroissance des cas de rage par unité financière économisée (bénéfice). Ce paramètre est significativement plus élevé pour la stratégie conduite dans l'Etat A que pour celle conduite dans l'Etat B.*

Si nous utilisons le paramètre « bénéfice » pour classer les deux stratégies, la stratégie A est supérieure à la stratégie B.

INTRODUCTION

This study is part of a comprehensive research project intended to develop cost effective strategies for the control of rabies in fox populations. Prime objective of the research project is the development of strategies for the control of rabies in fox populations that are distinguished for their

- Cost Efficacy:
  - the chosen strategy uses the resources as efficiently as possible,
  - the chosen strategy delivers value for the resources expended,
- Stability:
  - the chosen strategy is resistant to uncertainties about the actual and future environmental conditions,
- Flexibility:
  - the chosen strategy can be adapted to changing environmental conditions with minimum expenditure.

We will set up a simulation program that is expected to support the development of a strategy that fulfills the postulated requirements. The model development is composed of three steps:

1. Studies concerning the assessment of the strategies of oral immunization of fox populations in Germany:
   - costs of strategies,
   - effectiveness of strategies,
2. Studies concerning the epidemiology of rabies in fox populations:
   - modelling the dynamic of fox populations in time and space,
   - modelling the spread of rabies in fox populations in time and space (Thulke et al., 1997, Tischendorf et al., 1997),
   - modelling the partial impact of different immunization strategies upon epidemics of rabies and upon the population dynamics of fox,
3. Combination of the simulation programs with optimization algorithms:
   - use of traditional (Selhorst, 1995), genetic (Holland, 1992, Goldberg, 1989) and evolutionary (Schwefel, 1995, Bäck, 1996) algorithms, especially coevolution (Hillis, 1990), in order to determine effective immunization strategies.

The results of preliminary studies concerning the costs of the oral immunization strategies conducted in different states of the Federal Republic of Germany are presented now. Three questions are to be answered:

1. Do the costs for the implementation of different strategies differ when all costs are normalized to DM/bait?
2. Do the intensities (Covered area[%] x No. Baits per square kilometer [skm]) of different oral immunization strategies differ?
3. Do the benefits of different oral immunization strategies differ significantly?

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MATERIAL AND METHODS

This study is based on a questionnaire send to different state veterinary laboratories in Germany. The resubmitted questionnaires contain detailed information about the a) timing of the oral immunization campaign (date), b) kind of distribution of baits (by hand, by airplane), c) area covered with baits (square kilometres), d) kind of vaccine used, e) vaccine manufacturer, f) number of baits used/campaign, g) price per bait(DM), h) costs(DM) per campaign for using a airplane to distribute the baits, i) costs(DM) per campaign for the distribution of baits by hand, j) costs(DM) per campaign for the transportation and storage of baits, k) other costs (information, signs, etc.), l) costs for the personal at the veterinary laboratories (DM/campaign), m) costs (DM/campaign) for the diagnostic investigations (IFT, OTC / TC, SNT), prize for foxes shot by hunters (DM per fox), number of investigated foxes per year.

To answer the first and the second question nonparametric splines were used to smooth the data. With respect to the first question only the costs for the bait (BAIT), the distribution of the baits by hand or by plane (DISTRIBUTION), for the transportation and storage (LOGISTIC) and the costs for signs and information material (OTHER) are considered. These costs are directly related to the implementation of an oral immunization strategy. All costs are given in (DM/Bait).

The third question is answered using the model f(x) = a exp(-n x) in order to describe the decay f(x) in rabies cases in realtion to the accumulated costs per year (x).

All statistical analysis is done using SAS V.6.09.

RESULTS AND DISCUSSION

Two different states are selected in order to evaluate their immunization strategies

1. State A: 100% coverage (except year 1991), 20 baits/skm (except year 1991),
2. State B: adjusted coverage (the immunization area and the number of baits/skm was adjusted to the actual number of positive rabies cases in fox populations) .

The results of the evaluation are shown in figures one, two and three.

It is seen from figure 1 that the bait itself mainly contributes to the total costs/bait, followed by distribution, other and storage. The observed costs neither differ considerably with time nor with state.

Figure 1
Time dependent development of costs for implementation of immunization strategy
(a) State A, (b) State B

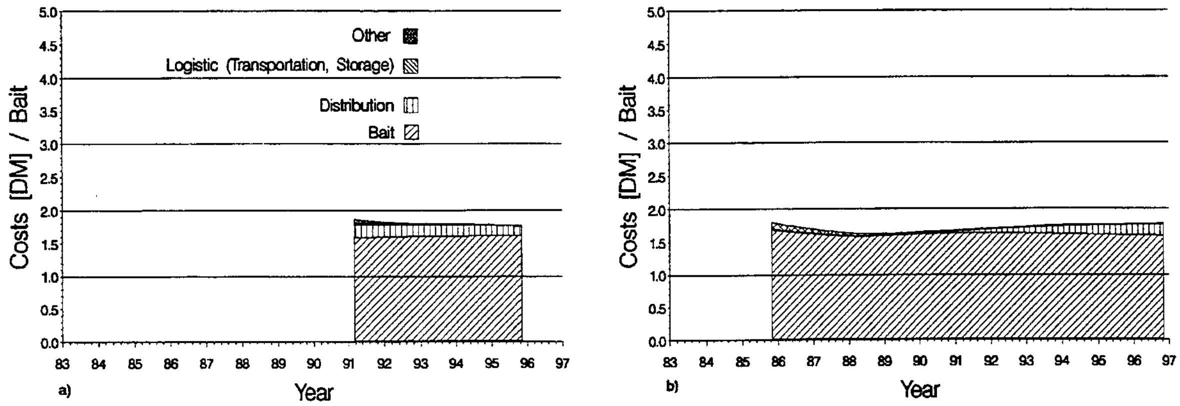


Figure 2 exhibits that different intensities were realized in both states. In state A, a time invariant strategy with an high intensity was realized since 1992. This strategy was not changed even when rabies cases decreased. In state B the oral immunization strategies were adjusted to actual number of rabies cases: the intensity was lowered when the number of of rabies cases decreased, the intensity was enhanced when the number of rabies cases increased.

In order to assess the benefits of the different strategies we examined the dependency between rabies cases and the accumulated amount of money already spent (Figure 3). In this figure the observed numbers of rabies are shown. The exponential function f(x) = a exp(-n x) fits the data quite well (Coefficients of determination: R^2=0.99 and 0.66 for State A and State B respectively). In this equation n is the most important parameter because it describes the rate of decay in rabies cases per unit money spent already. In state A the figure of this parameter is 0.835 (95% confidence limit: 0.746 - 0.925) in state B, parameter n equals to 0.188 (0.06 - 0.315). The rate of decay is significantly higher in State A than in state B.

On the basis of this result we propose that the strategy conducted in State A exhibits a significantly larger effectiveness (e.g. benefit) than the strategy conducted in state B. The reasons for this difference will be analysed in detail.

Figure 2
Intensity (Covered area [%] x No. Baits/skm) vs Year

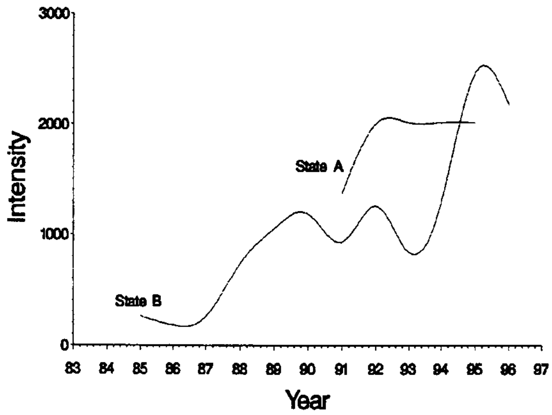
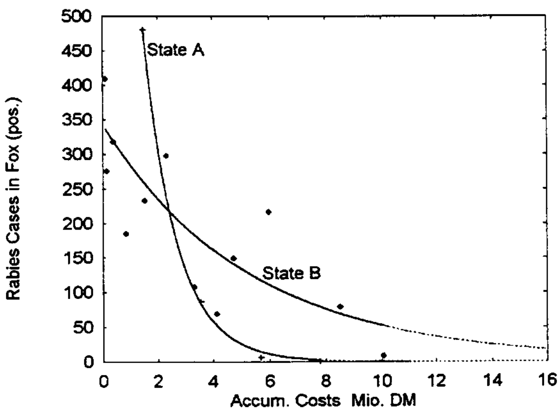


Figure 3
Rabies cases (number] in fox populations in relation to the accumulated costs [Mio. DM] (dots). Fitted exponential function f(x)=a exp(-n x) (lines). (dotted lines : prediction)



BIBLIOGRAPHY

Bäck, T., 1996. Evolutionary Algorithms in Theory and Practice. New York: Oxford University Press.

Goldberg, D.E., 1989. Genetic Algorithms in Search, Optimizatioin, and Machine Learning. Reading/MA: Addison Wesley.

Holland, J.H., 1992. Adaption in Natural and Artificial Systems. 2nd ed., Cambridge/MA: MIT Press.

Hillis, W.D., 1990. Co-evolving parasites improve simulated evolution as an optimizatioin procedure. Physica 42, 228-234.

Schwefel, H.-P., 1995. Evolution and Optimum Seeking. New York: John Wiley & Sons.

Selhorst, Th., 1996. Modelling, Simulation and Optimal Control of Insect Populations in Agro-Ecosystems. University of Bonn: Faculty of Agriculture (in German).

Thulke, H.-H., Tischendorf, L., Staubach, C., Müller, T. and Schlüter, H. Simulation based investigations on the consequences of the changed rabies spreading within immunised fox populations. Paris: ISVEE.

Tischendorf, L., Thulke, H.-H., Staubach, C., Müller, M.S., Jeltsch, F., Grimm, V. Goretzki, J., Müller, T., Schlüter, H. and Wissel, C., 1997. Change and risk of controlling rabies in large-scale and long-term immunised fox populations. Submitted for publication.