4. MISCELLANEOUS ARTICLES

4.1 How to do the wrong thing with the highest possible precision - a reflection on the use of GPS in rabies vaccination campaigns

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Introduction

The use of the Global Positioning System (GPS) was featured prominently in the discussion at the conference for the co-ordination of rabies vaccination campaigns in western Europe on 30 January, 1998. The use of GPS in the aerial distribution of vaccine bait has marked an important advance in rabies vaccination over the past two years. However, we must not ignore the fact that GPS is no more than a tool to enhance and measure the precision of the bait delivery system, and that – if the bait delivery plan *per se* is wrong, the use of GPS will do nothing to improve it. In this article, we will reflect on the use of GPS in aerial distribution of rabies vaccine baits and the significance of the design of the bait distribution strategy underlying the technical system. As Switzerland does not use aerial bait distribution or GPS, our contribution may look provocative; and indeed – we hope to provoke thoughts on the strategy of baiting and the plot of bait distribution rather than concentrating on the technical instruments.

Advantages and limits of GPS

For the Global Positioning System, a number of transmitter satellites circle the earth, allowing any GPS receiver on the earth to compute its own position by relocating the satellites. The accuracy of a GPS location can be within a few meters, depending on the number of satellites within the range of the receiver and on the availability of reference receivers at known positions. If a fixed-wing plane equipped with an autopilot, a GPS receiver, and an automatic device to discharge the baits is used for the distribution of the rabies vaccine baits, the plane's position at the ejection time can be determined within some meters. There is an additional uncertainty of the final position of the bait caused by shift while falling. Normally, the position of the plane at the time of bait launching is recorded by means of a computer, permitting the subsequent plotting of a map showing the flight route and the position of each bait discharged. There can be no doubt that the GPS has considerably improved the documentation of bait distribution. However, a good documentation of the distribution is not synonymous with a good distribution strategy. On the contrary: if the plan is inappropriate, it may even be disadvantageous to follow it too exactly. A few years ago, the distribution of vaccine baits by means of a plane guided by a pilot with an aerial map on his knees and an airsick human launcher in the back was a rather stochastic act, even if the team in the aeroplane tried to stick to the plan as close as possible. However, this "random" release of vaccine baits resulted in a wider distribution of the baits which may have been better than the strict dropping of the baits along a straight line.

The importance of the bait distribution plot

A few simple graphic models serve to illustrate our concern. An aerial baiting system generally follows the design shown in Fig. 1a: In an area with a given distribution of a target species – in our example territorial red foxes – parallel lines are flown, along which the baits are dropped. Two parameters define the distribution of the baits: (1) the distance between the lines, and (2) the distances between the baits. A typical layout may be to fly lines at a distance of 1000 meters, dropping a bait every 67 meters, which results in a overall bait density of 15/km^2 (Fig. 1a).

The principle of oral vaccination against rabies is for every fox to have access to vaccine baits. If a target species such as the red fox has a territorial tenure system, enough baits for all animals residing within a territory must be dropped there. Although this is a simple and obvious axiom, knowledge about the distribution and abundance of the vector species has rarely been available for the consideration of the design of the vaccination campaigns. Consequently, bait distribution and density have been determined empirically. Although this empirical approach has most often turned out to be efficient and successful, there is one big danger: If the preconditions change, the system may no longer work, the reasons for its failure may not be obvious.

If the vaccine baits are delivered by hand or by helicopter, the strategy is to distribute them as evenly as possible. In this case, the availability of baits to any individual fox is mainly defined by the bait density and the intra- and interspecific competition for baits. The fixed-wing plane however does not favour a dispersed distribution, and as a consequence, the distribution (together with the density) of the baits becomes an important factor regarding the availability of vaccine baits to the target species. Furthermore, the row of baits has the effect that an animal can specialise to find the baits. The straighter the line and the shorter the distance between two baits, the easier it will be for an individual fox or even a wild boar to pick up a number of them.

In recent years, many European countries have had problems with the efficiency of the oral vaccination of foxes against rabies because of the increased fox abundance. In many places, fox densities are believed to have increased 5-10 times since the first application of oral vaccination. The usual response to these problems was to increase the number of baits dropped per km^2. If the baits are distributed by fixed-wing planes, this aim is achieved by increasing the number of baits released per kilometer flown. To simply decrease the distance between single baits may, however, not have the desired effect. Fig. 1b shows a situation with a two-fold density increase for both foxes and baits. We assume that the size of the fox territories decreases linearly with the increased fox density. Although the overall ratio "baits per fox" remains the same an in the example shown in Fig. 1a, many fox territories in Fig. 1b do not get any vaccine bait, because the mean diameter of a fox home range is now less than 1000 meters, and hence a home range may fall between two lines. In such a situation, it would be much more reasonable to decrease the distance between the two lines than the distance between the baits. Fig. 1c shows the same increase of the fox and bait density as assumed in Fig. 1b, but with a different distribution of the baits. In the Fig. 1c example, every fox home range receives some baits.

We are aware of the fact that the relation between fox density and home range size is not simply a linear one. On the other hand, fox density can also increase because of a change in the social system, resulting in more individuals per territory. Furthermore, not every fox uses the entire territory within the few days the vaccine baits are available and effective, therefore the real temporary range of an individual fox might be much smaller than the family's territory. Furthermore, the distribution and shape of fox territories are not random, as in our models, but will be influenced by the distribution of ecological resources, suitable habitat, and natural and artificial barriers. Our model is simplistic, whereas reality is very complex. This complexity calls even more for a careful design of the baiting system and for a distribution plan adapted to the local fox population.

A vaccination system should never be repeated uncritically just because it proved to be successful in another place or at a different time. The efficiency of a bait delivery system depends on the habitat, the landscape, and the fox abundance. Some or all of these parameters differ between localities, and the baiting system has to be adapted to the local conditions. Unfortunately, we often lack the socio-ecological information about the local fox population needed to adjust the vaccination system, and hence have to start out with a presumable plot and then improve it empirically. For the control and revising of a baiting system, an accurate documentation of the bait delivery can be crucial. And for this process, a GPS is a most efficient tool.

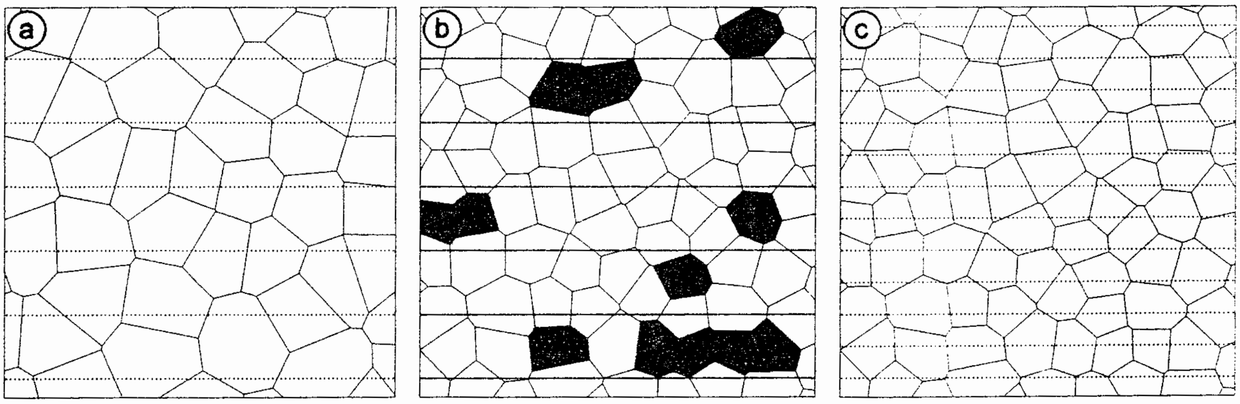

Figure legend:

Fig. 1. Model of fox territories (shown as polygons) and bait distribution along parallel lines flown by a fixed-wing plane. The fox territories were plotted randomly within a pre-defined range. The parameters used are:

a) Mean size of fox territory: 1 km^2 (range 0.5-2.0 km^2); distance between flight lines: 1000 m; distance between baits: 67 m; bait density: 15 km^2. All territories receive at least a few baits.

b) Mean size of fox territory: 0.5 km^2 (range 0.25-1.0 km^2); distance between flight lines: 1000 m; distance between baits: 33 m; bait density: 30 km^2. Some territories (dark shaded) will not receive any baits.

c) Mean size of fox territory: 0.5 km^2 (range 0.25-1.0 km^2); distance between flight lines: 500 m; distance between baits: 67 m; bait density: 30 km^2. All territories receive vaccine baits.