Some factors affecting the oral rabies vaccination of free-ranging carnivores

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Summary: Conditions which affect the outcome of oral rabies vaccination programs include environmental factors, and the behaviour, population densities and dynamics of target and non-target species. Examples are given from recent research and the literature.


INTRODUCTION

Strategies for delivering oral rabies vaccine baits to free-ranging carnivores are governed by six principal components: environmental factors, the behaviour and population densities and dynamics of target and non-target species, vaccine development, economics and the impact of human beings. This paper briefly describes how environment, animal behaviour and population factors can influence the efficacy of baiting programs, and provides some examples which illustrate the importance of these elements.

ENVIRONMENTAL FACTORS

A knowledge of habitat types preferred by carnivores is a prerequisite for distributing vaccine baits such that maximum bait uptake is achieved. For example, baiting by aircraft using uniform rates of bait application over varied landscapes is not very efficient for use with red foxes (*Vulpes vulpes*), which are known to prefer “edge” habitat and most often travel along the interface between wooded areas and open fields (1). Raccoons (*Procyon lotor*) in western Tennessee favoured sites near water and large trees where densities were 16.1-18.3 raccoons per km² in lowland deciduous forests and only 0.8-1.4/km² in upland pine-deciduous tree habitats. Densities were 2 to 11 times higher in habitats closer to permanent water and also higher along deciduous-lined shores (5). Similarly, variations in habitat between geographically distinct areas support widely different densities of striped skunks (*Mephitis mephitis*) (8, 13). Also, raccoon and skunk densities are often higher in urban areas where food and shelter are more available than is normally the case in rural habitats (9). Thus, a knowledge of the carrying capacity and limiting environmental factors for major habitat types will enhance efforts to reach 70-75% of target populations with vaccine baits (15).

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The relative abundance of target and non-target species is important, as the latter may compete for and remove significant numbers of baits. For example, in a Tennessee study, 12 raccoons and 73 opossums (*Didelphis virginiana*), or six times as many opossums as raccoons, were live-trapped in one area where raccoons occupied only 31.5% of the available habitat while opossums were found almost everywhere (98.9%) (4). Such conditions would make it difficult to deliver vaccine baits to raccoons effectively and economically, unless special baiting strategies were devised, e.g. species-specific baits or bait placement. Conversely, another study showed that although crows (*Corvus brachyrhynchos*) removed many baits, this did not appear to adversely affect the percentage of red foxes which consumed baits (1).

**BEHAVIOURAL FACTORS**

Behavioural considerations such as seasonal inactivity, communal denning, food preferences and feeding behaviour are important determinants of baiting success. For example, skunks and raccoons are generally inactive during the cold winter months in the northern United States of America and Canada (8, 10). Raccoons are reluctant to move during periods of snowfall (12) and baiting at such times would not be productive. Bait distribution during parturition, when females are less active, may result in fewer females receiving baits. Eighty percent of the raccoons trapped (n = 75) in conjunction with bait tests in late April and mid-May on a barrier island (Sapelo) in Georgia were found to be males. The test inadvertently coincided with the seasonal peak of raccoon parturition (10) and it was likely that a low percentage of the females within the population encountered baits because of their restricted movement (unpublished findings). Striped skunks are reported to use communal dens, and the potential for targeting such sites for baiting when animals are concentrated should not be overlooked. For example, a Minnesota study found 202 instances of communal denning by thirteen radio-collared striped skunks (3).

Carnivore feeding behaviour can influence bait acceptance and the success of vaccination efforts. The extent to which a species is an omnivorous or specialized feeder, the seasonal availability of natural foods, year-to-year variations in food abundance and competition for food (and baits) can all significantly affect vaccination rates. The size and friability of baits and the manner in which they are consumed by carnivores are also important; only portions of baits may be eaten and vaccine containers within baits may be selectively rejected intact or punctured and the contents leaked onto the ground. For example, red foxes in Ontario (Canada) ate baits and ingested vaccine from blister packs contained within baits (1). However, the same bait was less well accepted by raccoons and striped skunks, and these species were less likely to puncture blister packs and thereby receive immunizing doses of vaccine (R.C. Rosatte, personal communication). Conversely, captive raccoons which were offered a different bait type containing a wax vaccine container consumed both and were vaccinated (6).

Daily and seasonal differences in carnivore activity periods as they relate to reproduction, food availability or food seeking may influence bait uptake. Baits targeted for mongooses (*Herpestes auropunctatus*) in Antigua (West Indies) and left overnight, were taken in significant numbers by nocturnally active house mice (*Mus musculus*). However, when identical baits were placed out in the morning and checked later in the afternoon of the same day, tracking tiles revealed that 78-91% of the baits...
had been removed by diurnally active mongooses (7; unpublished findings). A study on
the island of St Croix (Virgin Islands) showed that mongooses visited an artificial feeder
for food an average of 15 times an hour during a dry period when food was scarce, but
less than once an hour during a wet period when natural food was abundant (7).

**POPULATION BIOLOGY**

Data relating to population dynamics are important for an understanding of the
biological processes which affect oral vaccination of carnivores. For example,
productivity and population turnover rates will determine how often vaccine baits must
be applied if a given percentage of the population is to be kept immunized. Similarly,
population density plays an important role in baiting strategy. For instance, using mean
population densities of 1, 10, and 500 animals per km$^2$ for red foxes, raccoons, and
mongooses, respectively, it is apparent that species-specific baiting techniques will be
required. In addition, assuming that the number of baits distributed must be 10-15 times
greater than the number of animals present in an area (to allow for non-target bait
removal, baits never found, etc.), it is obvious that the cost of baits, vaccine and labour,
and the method of bait distribution will vary greatly, as indeed will decisions on whether
or not to implement control efforts. All costs being equal, it would cost 10 times more to
reach raccoons than red foxes in a similar area based on average densities reported for
the two species. Furthermore, densities of a given carnivore species may vary more than
fifty-fold between geographic areas, e.g. 0.5 skunks/km$^2$ in Alberta and 26/km$^2$ in Illinois
(8). Such variations suggest that something should be known about relative or absolute
densities before bait placement, to minimize the number of baits required to achieve the
desired effect.

The home range size of a species, whether it defends territory or not, and whether
individuals travel in groups or singularly will influence, in part, the manner in which
baits are distributed. In the northern central plains of the United States of America,
mean home ranges of coyote, raccoon, red fox, and striped skunk have been estimated
at 9.5, 2.5, 1.5 and 0.8 km$^2$, respectively (A. Sargeant, personal communication). The
mean home range of mongooses in the Caribbean has been estimated at 0.037 km$^2$
(R. Lord, personal communication). Such differences between species, along with
varying population densities, play an important role in determining baiting strategies,
e.g. bait density and methods of dispersion. Movement behaviour will also determine, in
part, the potential for selective and species-specific tactics such as pre-baiting or the use
of central point bait stations to concentrate animals and thereby increase baiting
efficacy. The extent of animal movement and seasonal migration or annual dispersal of
young, whether individuals within a population are resident or transients seeking a
permanent niche, and the movement of rabid animals, all affect control strategies to
varying degrees. A study in North Dakota, in which striped skunks were live-trapped,
tagged, released and recaptured the following year, showed that 43% of the adult
females were recaptured compared to only 11% of the adult males and 9% of all
juveniles. Dispersal distances were surprisingly great (average 62 km, range 10-119 km)
for a species of such small physical size (11). Long dispersals have also been reported for
other rabies carriers such as the Arctic fox (*Alopex lagopus*) (2) and the red fox (14).

It is apparent, even from this cursory discussion, that a broad array of environmental
factors, animal behaviours and population parameters are important determinants of
the degree to which oral rabies vaccination programs will achieve success. Vaccination
technology, economics and the human element are also important contributing factors. While much progress has been achieved to date, further study is needed to determine when, where and how oral vaccination of free-ranging carnivores should be performed, and under what conditions vaccination can control the disease in nature.

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QUELQUES FACTEURS INTERVENANT DANS LA VACCINATION ANTIRABIQUE PAR VOIE ORALE DES CARNIVORES VIVANT EN LIBERTÉ. – S.B. Linhart.

Résumé: Les conditions qui peuvent compromettre le succès des programmes de vaccination antirabique par voie orale concernent principalement les facteurs liés à l’environnement, au comportement des animaux, à la densité et à la dynamique des populations des espèces cibles ou non cibles. L’auteur examine des exemples rapportés dans la littérature ou ayant fait l’objet de recherches récentes.


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FACTORES QUE PUEDEN AFECTAR LA VACUNACIÓN ANTIRRÁBICA POR VÍA ORAL DE LOS CARNÍVOROS QUE VIVEN EN LIBERTAD. – S.B. Linhart.

Resumen: Las condiciones que pueden afectar el éxito de los programas de vacunación antirrábica por vía oral incluyen factores relativos al medio ambiente, al comportamiento, a la densidad y a la dinámica de las poblaciones de las especies meta o no meta. El autor propone ejemplos sacados de la literatura y relativos a recientes investigaciones.


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REFERENCES


