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### Authors

Manzo, Amanda  
Theimer, Tad  
Delph, Robert  
[et al.](#)

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# A Preliminary Field Trial of Bait Stations for the Delivery of Oral Rabies Vaccine: Can Varying Diameter Exclude Non-Target Species?

Amanda Manzo, Tad Theimer, Robert Delph, John Hall, Nancy Hernandez, Brandon Holt, Maureen Maloney, and Mayra Moreno

Northern Arizona University, Flagstaff, Arizona

David Bergman and Chad Heuser

USDA APHIS Wildlife Services, Phoenix, Arizona

**ABSTRACT:** Delivery of oral rabies vaccine can be an effective method for combating rabies, but broadcasting vaccine sachets over wide areas creates the potential for non-target species to ingest vaccine baits before the target species encounters them. An alternative is to present the vaccine at a bait station designed to allow access by target species, while excluding some non-target species. We tested whether bait stations constructed of PVC pipe of 3 different diameters (10, 15, and 20 cm) differed in their effectiveness in allowing access by striped skunks versus other, non-target, nocturnal mammals in the urban environment of Flagstaff, Arizona. We placed bait stations in sets of 3 at 13 locations during late February and early March 2005 and monitored their use for 5 nights using digital still cameras. We recorded visits by striped skunks, gray foxes, raccoons, and domestic cats and dogs. Large-diameter tubes were used by all species, though large dogs had limited access, and small-diameter tubes were entered only once (by a skunk). Medium-diameter stations were used by all species except dogs, but skunks entered these stations more readily (81% vs. 44% or less), indicating that baits in 15-cm tubes would be more readily accessed by skunks. If striped skunks are the primary target species, we recommend the use of medium-diameter bait stations, as these stations excluded all dogs and reduced bait uptake by cats, foxes, and raccoons. If foxes and raccoons are also targeted, large-diameter stations will be required, and these will be available to all cats and some small dogs but should exclude larger dogs. Given the cost of this type of bait station in both time and money, we recommend their use only in limited areas where potential interaction with non-target species is of special concern. However, when one considers the value of human life, the cost may be negligible.

**KEY WORDS:** bait station, oral rabies vaccine sachets, rabies, skunk, urban wildlife, vaccine

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## INTRODUCTION

Wild carnivores continue to serve as important reservoir hosts for multiple variants of the rabies virus. In North America, striped skunks (*Mephitis mephitis*), raccoons (*Procyon lotor*), coyotes (*Canis latrans*) and red (*Vulpes vulpes*) and gray foxes (*Urocyon cinereoargenteus*) are important reservoir species, with different species acting as the primary reservoir in different regions (Krebs *et al.* 2004). In Arizona, for example, foxes are considered the primary reservoir species in the southern part of the state, but recent outbreaks of a bat variant among skunks have been recorded in the northern part of the state, making skunks the main terrestrial vector of rabies in Arizona (Engeman *et al.* 2003).

Oral rabies vaccination (ORV) of targeted carnivore species is an important addition to conventional rabies control strategies (Slate *et al.* 2005). Although live trap-vaccinate-release programs to manually vaccinate wildlife provide information about the spatial distribution of the species, they are costly and slow in response to the virus (Rosatte *et al.* 1992, Engeman *et al.* 2003). In contrast, ORV has been used successfully against fox rabies in Europe (Steck *et al.* 1982, Wandeler 2000) and Canada (McInnes *et al.* 2001), against raccoon rabies in the eastern United States (Roscoe *et al.* 1998), and against gray fox and coyote rabies in Texas (Slate *et al.* 2005).

Avoiding uptake of baits by non-target species, especially domestic animals, is an important challenge of

any ORV program in urban areas (Guthery and Meinzer 1984, Slate *et al.* 2005). For example, Hegglin *et al.* (2004) measured vaccinated bait consumption by urban red foxes and found that foxes took 48% of available bait, while the rest was taken by non-target species, including feral cats (*Felis domesticus*). Avoiding uptake by non-target species can be accomplished by varying the type of bait or bait placement, or by using bait stations designed to allow access by target species but not by non-target species. Our goal in this study was to test a relatively simple bait station design that limited access to bait, based on animal body size, by placing baits in PVC tubes of varying diameters.

## MATERIALS AND METHODS

We monitored the ability of animals to access bait placed in bait station tubes constructed of PVC pipe of 3 different diameters (10, 15, and 20 cm) (Figure 1) using Leaf River Outdoor™ digital 35-mm trail cameras with motion sensors. Sets of 3 tubes, 1 of each tube size, were placed side by side and baited with unvaccinated canned cat food at 13 sites within Flagstaff city limits during the spring (February to March) 2005. Two cameras were operated for 12-14 hours at night (18:00 to 0:800) for 5 days at each site. Cameras were positioned to photograph both the area around each station and the inside of all 3 tubes, so that animals' approaches and bait consumption could be assessed from each still photograph. Relative



**Figure 1. Striped skunk entering the 15-cm diameter tube of a bait station in urban Flagstaff, Arizona. Each station included one small (10-cm diameter), one medium (15-cm diameter), and one large (20-cm diameter) tube baited with canned cat food.**

use of each size of tube was calculated for each species as the number of times an animal entered a particular tube size to consume bait divided by the number of times bait was available in that tube size while the species was present.

**RESULTS**

Over all 13 sites, we obtained photos of animals at bait stations 159 times. Five species were recorded, including striped skunk, raccoon, gray fox, domestic cat, and domestic dog (*Canis lupus familiaris*). Domestic cats were recorded more than any other species with 65 approaches, and they visited 10 of the 13 sites. Striped skunks were recorded a total of 39 times at 12 sites. Gray foxes were recorded 27 times at 8 sites. Raccoons were recorded 19 times at 7 sites, and a total of 9 approaches by dogs were recorded at 5 sites.

All 5 species were recorded entering the largest tubes. All species except dogs entered the medium stations, while the small-diameter tube was entered only once, and that was by a skunk. The percentage of baits taken from each of the 3 tube diameters differed by species (Table 1). When the proportion of baits taken from large tubes was used as a baseline, medium tubes (15-cm diameter) reduced bait uptake by skunks, raccoons, cats, and foxes by 19%, 40% 63%, and 63%, respectively. A total of 88% of the skunks we recorded took baits from the

medium-diameter tube, compared to none of the dogs, 33% of cats, 29% of foxes, and 56% of raccoons.

**DISCUSSION AND MANAGEMENT IMPLICATIONS**

In urban areas, competition for baits usually arises between dogs, cats, and wild animals (Hadidian *et al.* 1989, Andelt and Woolley 1996, Roscoe *et al.* 1998) and thus could hinder the effectiveness of vaccine uptake (Guerra *et al.* 2003). In our study, dogs were recorded infrequently, but those we did record rarely accessed baits, except from the largest-diameter tube. Few dog breeds are small enough to enter medium-sized tubes, so this size should exclude most dogs. However, we did document 1 dog chewing and tearing at a bait station until the bait fell out one end, so unless bait stations are held in place by wires and stakes, dogs and larger carnivores such as coyotes could potentially access some baits in this manner.

In contrast to dogs, domestic cats were recorded at most sites and were the most common animal documented in photos. Although cats and skunks are relatively similar in body size, and both had relatively high rates of bait acceptance from the large-diameter tubes (88% and 100% respectively), bait acceptance from the medium-diameter tubes was markedly lower by cats, compared to skunks. Part of this difference may have been due to differences in motivation. Many of the cats we recorded were not feral and were probably well fed by their owners. Repeating this experiment in areas with high numbers of feral cats or during times of cat quarantines could better assess the ability of these stations to effectively reduce bait uptake by feral cats.

Among wild species, skunks had the highest rate of bait uptake from both large- and medium-diameter tubes. If uptake from these large-diameter tubes is used as a baseline, the reduction in uptake from medium-sized tubes was relatively small for skunks (19%), moderate for raccoons (40%), and relatively large for fox (63%). As a result, medium-diameter tubes reduce uptake of baits by these other wild carnivores relative to skunks.

Varying the attractant associated with ORV baits could be used in conjunction with bait stations, such as those we tested, to improve specificity. We used canned cat food as bait in our study, while most ORV are currently incorporated into poultry-based or fishmeal-based polymers or fishmeal-coated sachets (Slate *et al.* 2005). Although all 3 of these are meat-based and odoriferous, we did not test whether cat food might be a stronger attractant for cats than these other substances.

**Table 1. The number of times cats, dogs, skunks, foxes, and raccoons were recorded as present at bait stations when bait was available in tubes of 3 diameters (10, 15, and 20 cm) (Present); the number of times each species accessed the bait (Bait Taken); and the percentage of times bait was taken.**

Tube Diameter (cm)	Cat			Dog			Skunk			Fox			Raccoon		
	Present	Bait Taken	%	Present	Bait Taken	%	Present	Bait Taken	%	Present	Bait Taken	%	Present	Bait Taken	%
20	43	38	88	7	2	28	24	24	100	10	8	80	11	8	73
15	54	18	33	7	0	0	31	25	81	14	4	29	16	7	44
10	65	0	0	9	0	0	39	1	2	27	0	0	19	0	0

However, some wildlife, such as skunks, are strongly attracted to non-animal baits like peanut butter, while other species, such as cats, are not. As a result, by placing peanut butter baits in medium-diameter tubes, uptake by cats, the major non-target species that we recorded entering medium-diameter tubes, would be reduced, while the attraction for target species such as skunks may remain relatively high.

### Caveats

Several aspects of the study design need to be considered when assessing these results. First, although we could often recognize individual dogs and cats based on breed or unique coat patterns, we could not distinguish individual raccoons, skunks, or foxes. As a result, our data for wild species may suffer from pseudoreplication, in that the same individual was most likely recorded more than once at each site. Even so, each wild species' response was generally consistent across sites, suggesting that the general patterns we report are relatively robust.

In addition, our tests were restricted to the months of February and March, a period of cold temperatures and relatively heavy snowfall that limits activity by rodents. At other times of the year, squirrels, rats, or mice could potentially interact with baits in smaller-diameter tubes, and cause loss of baits. Even if bait odors or flavors were not attractive to rodents, in areas where woodrats (*Neotoma* spp.) are present, baits could potentially be removed as part of their hoarding behavior. Thus, testing the efficacy of these tubes at different seasons would be warranted. In addition, use of bait stations in the winter and early spring may encourage target species to take baits, because their resources are limited at this season.

### Recommendations

Although the medium-diameter tubes used in this study reduced access to bait by domestic cats and dogs, they did not prevent access by cats. As a result, in areas with large cat populations, use of these tubes may reduce but not eliminate uptake by non-target domestic animals. Given the cost (approximately \$35 each) and time necessary to make and deploy PVC tubes such as those we tested, they will be useful only when oral vaccine is to be distributed over limited areas and where concern for non-target uptake is relatively high. In addition, multiple land ownership in urban areas, and safety issues of aerial vaccination drops, may make stations more useful than aerial sachet drops. Two improvements in design would be to lengthen the tubes to deter large animals from reaching into the tube to access bait, and to combine oral vaccine with attractants preferred by target species, such as peanut butter, which is less attractive to domestic, non-target animals.

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