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DOI: 10.7589/2016-11-245

Journal of Wildlife Diseases, 53(2), 2017, pp. 424–427

Bird Feeders as Locations for Skunk Uptake of Oral Rabies Vaccine Baits

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ABSTRACT: Significantly more (54%, P=0.003) placebo baits placed under 26 bird feeders in Arizona, US were removed by striped skunks (*Mephitis mephitis*) than at paired, nonfeeder locations (19%). Baiting at bird feeders could supplement traditional oral rabies vaccine bait placement in urban-suburban areas while engaging the public in rabies control efforts.

Rabies management in striped skunks (*Mephitis mephitis*) has traditionally focused on population reduction or trap-vaccinate-release with inactivated vaccines (Rosatte et al. 1986, 1992). However, development of ONRAB® (Artemis Technologies, Inc., Guelph, Ontario, Canada), a live, recombinant human adenovirus (AdRG1.3) rabies virus glycoprotein vaccine, and promising field tests of this vaccine, should result in more-widespread use of oral rabies vaccination (ORV) in combating skunk rabies (Fehlner-Gardiner et al. 2012; Brown et al. 2014). One challenge facing ORV is bait deployment in residential areas, where aerial bait drops are impractical or too expensive (Slate et al. 2005), and ORV baits are instead distributed by hand in parks, ravines, culverts, or near abandoned buildings or dens. Lower uptake of baits in residential areas than in rural areas has been hypothesized to be due to either reduced attractiveness of baits because animals have access to abundant anthropogenic food or to the fact that fewer baits can be distributed (Mainguy et al. 2012). Developing additional strategies for distributing baits in residential areas will be important in increasing the efficiency of ORV (Slate et al. 2005). Striped skunks regularly visit areas below bird feeders where spilled seed has accumulated, suggesting that these areas could serve as foci for ORV bait deployment (Theimer et al. 2015). We tested this hypothesis in suburban neighborhoods of Flagstaff, Arizona, US (population=65,000, elevation=2,170 m, 35°11′57′′N, 111°37′52′′W) and Sedona, Arizona, US (population=10,200, elevation=1,372 m, 34°52′15′′N, 111°45′38′′W) between June and September 2015. We recruited homeowners with bird feeders through an email solicitation through the Northern Arizona Audubon Society or by walking door-to-door in target neighborhoods. We received 21 responses through the Audubon Society within 48 h of sending our request, of which 11 were appropriate for our study. Roughly 1 h was needed to find the appropriate contact, draft, and send the initial query, resulting in 11 feeders recruited/h effort. Of the 110 houses visited, 57 residents were not at home, 41 were not interested, and 16 volunteered. Six had bird feeders that could be used in our trials. Total time surveying was 10 h for a rate of 0.6 feeders recruited/h effort. We recruited nine additional volunteers by word of mouth spread by the 17 original volunteers.

For each feeder, we chose a paired location within 500 m that represented an area where a bait would typically be dropped via hand-baiting (e.g., culvert openings, alleys, undeveloped lots) but within the suburban matrix. We placed one placebo ONRAB bait at each feeder and reference location and monitored the bait with an infrared-triggered trail camera (Ambush IR, Cuddeback, De Pere, Wisconsin, USA; infrared LED flash, trigger time <0.5 s) set to take both still and video clips (5 megapixel resolution) with 5-s delays between triggers. The placebo was an elongated plastic blister pack (30×14×10 mm, ~4 g) coated with sweet-flavored attractant that contained water instead of vaccine. The initial bait was monitored for four nights with undisturbed baits retrieved on the fifth day. At feeders, homeowners monitored baits daily and replaced baits when removed or chewed. Because striped skunks in our area show variable pelage patterns, we could estimate the minimum number of unique skunks taking baits. We tested whether the number of initial baits removed was higher at feeders by using a chi-square contingency table analysis and the rate of removal using a Kaplan-Meier survival analysis in IBM SPSS Statistics for Windows (IBM Corp., Armonk, New York, USA).

Striped skunks took significantly more baits (χ^2=8.6, *df*=1, *P*=0.003) and removed baits faster from under feeders (χ^2=6.9, $P<0.01$; Fig. 1A). Uptake by nontarget animals was similar at feeder and nonfeeder sites (Table 1). When we included baits replenished on subsequent days at bird feeders, 27 uniquely patterned skunks chewed or removed baits at feeders, compared to five at nonfeeder sites (Fig. 1B), because rebaiting at feeders exposed baits to new individuals rather than to the same individual repeatedly. As a result, we found that placing baits below bird feeders on multiple nights or placing a bait dispenser below bird feeders (e.g., Boulanger et al. 2006), especially one that could deposit baits automatically at a preset rate (e.g., Smyser et al. 2015), could allow uptake by multiple skunks. Striped skunks were more abundant than raccoons (*Procyon lotor*), and opossums (*Didelphis virginianus*) were absent in our study areas, so whether our results apply in other urban areas remains to be tested. Boyer et al. (2011) hypothesized that the sweet flavor of the ONRAB baits may be less attractive to skunks but, in our study, all skunks that approached sweet baits carried them away or chewed them. Skunks may take baits more readily below bird feeders because they are already conditioned to find and consume food there, including novel foods.

Although homeowners in our study handled placebo baits, ORV baits containing live vaccine should be handled only by trained personnel because of human health concerns (Slate et al. 2014). Rather, we recommend

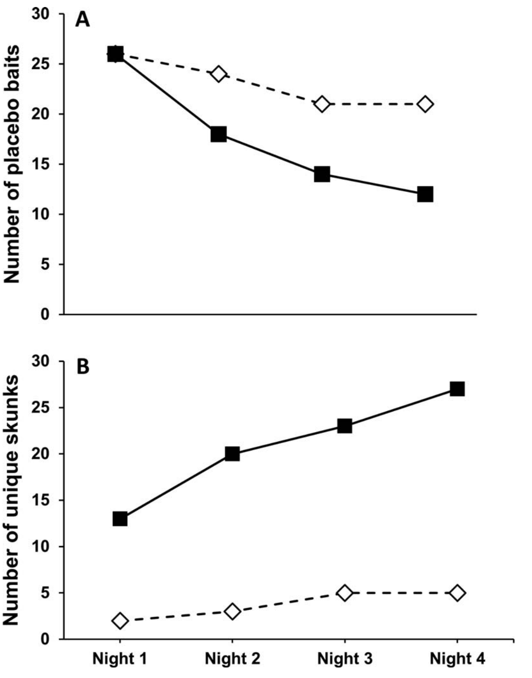

FIGURE 1. A. Number of initial placebo baits removed by striped skunks (*Mephitis mephitis*) over 4 nights when placed either under a bird feeder (black squares, solid line) or at a paired, nonfeeder site within 500 m (open diamonds, dashed line), in the suburban areas of Flagstaff and Sedona, Arizona, USA. The study was done in June and July 2015 to test the potential for bird feeders to act as locations to place baits with live, recombinant human adenovirus (AdRG1.3) rabies virus glycoprotein vaccine (ONRAB, Artemis Technologies, Inc., Guelph, Ontario, Canada). B. The total number of uniquely patterned striped skunks that chewed or removed a placebo bait over 4 nights when baits were replenished at bird feeders compared to the initial bait left at paired, nonfeeder sites.

homeowners be involved only in allowing access to their feeders and potentially monitoring when baits need to be replenished. Even so, involving them even to this limited extent is beneficial because meetings with homeowners allowed us to educate them about rabies and explain the rationale behind pet vaccinations and pet quarantine, and they quickly spread information among neighbors. Additionally, all our homeowners reported they would allow access in the future so, once identified, their homes could serve as locations where baits could be quickly deployed in future outbreaks. Public support is critical for

TABLE 1. Fate of placebo baits placed either under bird feeders or at nonfeeder locations to document uptake by target (striped skunk, *Mephitis mephitis*) and nontarget animals in suburban Flagstaff and Sedona, Arizona, USA. The study was done in June and July 2015 to test the potential of bird feeders to act as locations to place baits containing live, recombinant human adenovirus (AdRG1.3) rabies virus glycoprotein vaccine (ONRAB, Artemis Technologies, Inc., Guelph, Ontario, Canada). One bait was placed at each site initially ("initial bait") and additional ("subsequent") baits were placed under feeders after the initial bait was taken. Species listed are those that removed or chewed a bait based on still and video images.

Bait fate	No.		
	Initial bait, nonfeeder	Initial bait, feeder	Subsequent baits, feeder
Not touched	14	4	1
Striped skunk (*Mephitis mephitis*)	5	14	19
Rock squirrel (*Otospermophilus variegatus*)	3	1	1
Gray fox (*Urocyon cinereoargenteus*)	2	2	1
Javelina (*Pecari tajacu*)	1	1	3
American Crow (*Corvus brachyrhynchos*)	1	1	0
Raccoon (*Procyon lotor*)	0	2	3
Mallard (*Anas platyrhynchos*)	0	1	0
Mule deer (*Odocoileus hemionus*)	0	0	2
Total placed	26	26	30
Total taken (%)	12 (46)	22 (85)	29 (97)
Percent taken by striped skunks	19	54	63

successful rabies vaccination efforts (Rosatte et al. 1992), especially in residential areas where ORV is challenged by high human and mesocarnivore densities and limited options for distributing baits. Supplementing traditional ORV bait deployment strategies with baiting at bird feeders could increase both efficiency of bait uptake and the opportunity for educating the public.

We thank Artemis Technologies, Inc. for baits, the Northern Arizona Audubon Society, and the homeowners. This work was approved under Northern Arizona University Institutional Animal Care and Use Committee Protocol 11-002-R1.

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Submitted for publication 8 November 2016.
Accepted 10 December 2016.