Modifying M-44s to Reduce Risk of Activation by Swift Fox

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Tools and Technology

Modifying M-44s to Reduce Risk of Activation by Swift Fox

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ABSTRACT M-44s are spring-powered sodium cyanide ejectors commonly used in the United States to manage livestock depredation by coyotes (*Canis latrans*). While highly selective for canids, improvements could reduce risk to nontarget canids, especially State-Endangered or -Threatened canids such as the swift fox (*Vulpes velox*). In 2012–2013, we tested M-44s set at modified heights to determine whether height modifications reduced risk to swift foxes without reducing activation rates by coyotes. We presented captive coyotes housed at the USDA National Wildlife Research Center's Predator Research Facility, Millville, Utah, USA, with M-44s at various test heights to determine a height that would still ensure activation and then M-44s set at 15-cm height were placed in pens with captive swift foxes at the Cochrane Ecological Institute, near Cochrane, Alberta, Canada, to evaluate their ability to activate M-44s. M-44s were next set in the field as 31 matched pairs within North Dakota, USA. For each matched pair, 1 was set at standard height, where the body of the device was entirely below ground level and only the mouth piece was above ground, and 1 at a modified height, where the top of the mouth pieces was set 15–18 cm above ground level. Camera traps were used to monitor wildlife activity at M-44s. Despite equivalent visitation rates based on camera-trap data, only one modified M-44 was activated by a coyote, whereas 19 M-44s set at standard height were activated by coyotes. No swift foxes were observed during field trials, but red foxes (*V. vulpes*) were observed at 2 sets and did not activate the M-44s. Modifying the height of M-44s appears to reduce activation risk for nontarget canids, but also reduces the rate of activation by coyotes. Thus, height modifications to M-44s may not be practical or efficient in areas with little or no risk to nontarget canids because of compromised coyote activation rates, but should be considered as an option to enable use of M-44s for coyote management in areas where M-44s are not currently used because nontarget, small canids may co-occur. Published 2016. This article is a U.S. Government work and is in the public domain in the USA.

KEY WORDS *Canis latrans*, coyote, predator control, predator damage, *Vulpes velox*.

The M-44 is a spring-powered sodium cyanide ejector commonly used in the United States to manage predator damage (Blom and Connolly 2003). It has high selectivity toward killing canid species, and is registered in the United States for the control of coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), grey foxes (*Urocyon cinereoargenteus*), and feral dogs (*C. familiaris*; Connolly 1988). It is most commonly used for removal of coyotes in response to livestock depredation (Shivik et al. 2014). The device is selective because it can be baited with a lure that induces a bite-and-pull response in canids. Once pulled, the device activates to propel sodium cyanide powder into the back of the mouth, resulting in death of the animal (Connolly and Simmons 1984). While the device is used for lethal removal of select canids, there is risk of nontarget take by other canids because the lures used to elicit a bite-and-pull response are attractive to most canids.

It is important to identify ways to reduce nontarget species take in general, especially in areas where use of M-44s potentially overlaps with threatened or endangered canids. The swift fox (*V. velox*) is the smallest canid in North America and historically occupied short-grass and mixed-grass prairies of the Great Plains throughout central North America (Scott-Brown et al. 1987, Cypher 2003). Swift fox populations declined throughout its historical range during the late 19th and early 20th centuries (Scott-Brown et al. 1987), with it being warranted but precluded from listing as endangered by the U.S. Fish and Wildlife Service in the early 1990s (USFWS 1995). Recovery efforts enabled its removal from the federal candidate list, but the swift fox remains listed as endangered or threatened in some States (USFWS 2001, Sovada et al. 2009).

Habitat occupied by swift fox is often used by livestock where coyote management is also prevalent. Although take of swift foxes by M-44s is uncommon, it is important to identify modifications that further reduce or eliminate such nontarget

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risk. Modifications to M-44s have already expanded their use, selectivity, and efficacy, as evident from the study documenting M-44s equipped with a collar modification can deliver a consistent lethal dose of 1080, a toxicant, to red foxes in Australia (Busana et al. 1998, Marks et al. 1999). A plastic cylinder buried around each M-44 aided in their utility and selectivity in sandy soils on Philip Island, Victoria, Australia (van Polanen Petel et al. 2004). Our objective was to measure the effect of height modification of M-44s on coyotes and nontarget species such as swift fox. Our hypothesis was that height modification would reduce activation rate by nontarget species such as swift fox without compromising the activation rate by coyotes.

METHODS

To set a M-44 at a modified height, we lengthened the stake by welding additional material to the base (Fig. 1). This provided a secure base so that the coyotes and foxes could not pull the entire M-44 out of the ground. We took precautions during welding to not affect M-44 performance. Approximately 15–20 cm of additional stake was sufficient to set the M-44 at the modified height and secure the M-44 within the different soil types at both captive facilities and in field trials conducted in North Dakota, USA. All research met humane standards and was approved by the U.S. Department of Agriculture (USDA)-Wildlife Services-National Wildlife Research Center's Institutional Animal Care and Use Committee (QA-2018 and QA-2432).

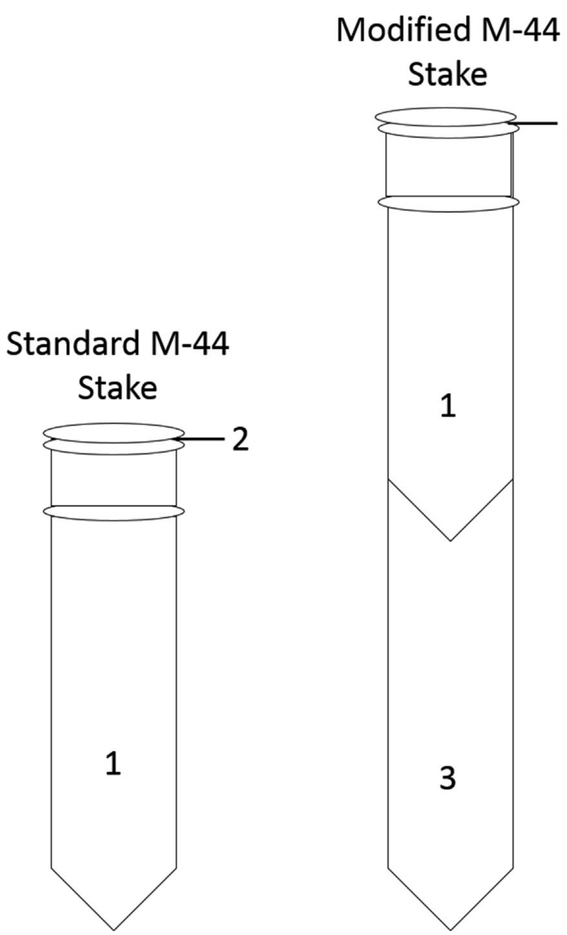

Figure 1. The bottom half of a M-44 toxicant ejector with (1) metal stake; (2) tension set device; and (3) modified stake length when set for height modifications (image not to scale). Modified height M-44s were used on captive coyotes at the U.S. Department of Agriculture-Predator Research Facility in Millville, Utah, USA, between 17 July and 18 August 2012; on captive swift foxes at the Cochrane Ecological Institute, near Cochrane, Alberta, Canada, between 13 and 19 November 2012; and at traditional M-44 sets placed throughout North Dakota, USA, between 19 February and 14 April 2015.

Captive Coyote Tests

We first conducted tests on captive coyotes housed at the USDA Wildlife Services National Wildlife Research Center Predator Research Facility in Logan, Utah, USA. The Facility houses up to 100 adult coyotes, kept as mated pairs, in outdoor enclosures of varying size. We used clover pens for these tests because they are optimal for direct observations (Mettler and Shivik 2007, Gilbert-Norton et al. 2009). We selected coyotes at random from all adult coyotes known to approach novel objects. During testing, we housed coyotes without their mates, alone, within a clover pen.

In general, M-44s can only be activated by an upward pull force of 1.6–2.7 kg (Connolly and Simmons 1984). In all captive coyote tests, we used lures to induce bite-and-pull behaviors, and set M-44s for maximum tension to aid in reducing the ability of swift foxes to pull and trigger (Connolly and Simmons 1984). We used a single lure, but if the coyote did not interact with the device, we used a new lure to attempt to attract the coyote to the device. We tested one coyote at a time to allow additional height modifications based on individual test responses. We first used the highest feasible setting of 30.5 cm based on body heights of captive coyotes and then lowered the setting if coyotes were unable to pull successfully at that setting. We set M-44s near the center of the pen, alongside an established trail. We randomized the side (north–south or east–west) of the trail. We recorded all tests with video cameras to assess interactions of the coyote at the M-44. We used capsules filled with cornmeal so that the tests were not lethal but facilitated identification of successful versus unsuccessful pulls. We tested captive coyotes until they interacted with the device or did not interact with the device even after 48 hr. If they interacted but did not successfully activate the device, we retested them at a lower height. We defined success as pulling the device from above to ensure the capsule's content would propel to the back of the mouth once activated.

We categorized coyote behavior as follows: 1) did not approach the M-44; 2) approached and investigated the M-44; 3) investigated and attempted to pull the M-44 but was unsuccessful at pull; or 4) was successful at pulling the M-44. We also tested all coyotes with a M-44 set at standard, ground level (0 cm). We determined the M-44 height that was equal to or slightly less than that at which all coyotes were able to successfully pull a M-44 for further tests with swift foxes.

Captive Swift Fox Tests

Once we determined a single test height, we sent the modified M-44s to the Cochrane Ecological Institute, near Cochrane, Alberta, Canada, for further testing on swift foxes. The Cochrane Ecological Institute had various outside enclosures for swift foxes. We set M-44s in 3, 8.1-ha pens, each housing a pair of swift foxes. We used camera traps to monitor activity at M-44s, which we placed along a well-used trail within each pen, randomizing placement per side (e.g., north/south or east/west) and baited with a single lure. We categorized fox behavior as follows: 1) did not approach the M-44; 2) approached and investigated the M-4; 3) investigated and attempted to pull the M-44 but was unsuccessful at pull; or 4) was successful at pulling the M-44. In all tests, we used cornmeal capsules so that no captive foxes would be killed if they pulled the M-44. We also set M-44s at maximum tension and with a gauze-and-wax top of 3.81 cm in diameter to aid in reducing the ability of swift foxes to activate the device. The gauze top and maximum tension were regularly used by USDA Wildlife Services personnel in Wyoming, USA, where swift fox may occur (R. Krischke, U.S. Department of Agriculture Wildlife Services, personal communication).

Field Trials

We tested modified devices in North Dakota where M-44s were already being placed to reduce livestock depredation by coyotes. Swift foxes were historically present in North Dakota but are rare currently because there are no known breeding populations (Sovada et al. 2009). Wildlife Services Specialists typically set multiple M-44 devices in a relatively small area, referred to as a M-44 station, such that 1–4 M-44s may be set within 1–10 m of one another. For this study, we set $\geq$1 M-44/station at the modified height. Although some stations included multiple M-44 devices, we randomly assigned one device set at normal height as the matched pair for the modified-height M-44. We used camera traps to record visitation rates (Shivik et al. 2014). In brief, we set cameras 4–15.5 m from devices where an appropriate fence post or tree for mounting was found, installed 0.5–2 m above ground, and programmed to record 3 images/trigger in 1-second intervals for 24 hr/day. Specialists checked M-44s at least once per week and checked cameras, changed memory cards and batteries for cameras as needed, recorded the dates for which the M-44s were set or checked, recorded which lures were used, and recorded which M-44s were visited or activated by animals. Although Specialists were allowed to use a variety of commercially available lures, the same lure was used for the 2 matched M-44 devices within the same set. We reset M-44s as needed during weekly station visits. We used camera-trap photographs to determine the minimum number of coyotes visiting M-44 sets, which category of interaction occurred at each visit, and other species that visited sets. We used a Chi-square test to determine whether the minimum number of visits by coyotes recorded by camera traps differed between activated and not activated modified and standard M-44s.

RESULTS

Captive Coyote Tests

We tested 6 adult coyotes (4 F, 2 M) at the Predator Research Facility. We conducted tests between 17 July and 18 August 2012. We tested the first coyote with a M-44 at 30.5 cm. After 1 hr of observations, it appeared that the height was too high for the coyote to pull upward and activate the M-44. Although the coyote could investigate the device (i.e., sniff; Category 1) from above, it appeared unable to bite or pull upward; instead, it turned its mouth sideways when it attempted to bite the M-44 (Category 2). Thus, we lowered the M-44 to 25.4 cm. The coyote successfully pulled the M-44 when it was set at 25.4, 20.3, and 0 cm. At 25.4 cm, the coyote used a side-mouth pull (Category 3). At 20.3 and 0 cm, the coyote pulled from the top (Category 4).

We tested the second coyote with the M-44 set at 22.9 cm. The coyote rubbed on the M-44 repeatedly (Category 1), so we changed to a different lure after 3 hr of observation. The coyote successfully pulled the M-44 from the top (Category 4). We reset the M-44 at 17.8 cm and the coyote was again successful at pulling the M-44 from the top (Category 4). The coyote also successfully pulled a M-44 from the top at 0 cm (Category 4).

We tested the third coyote with the M-44 set at 22.9 cm. The coyote successfully pulled from the top (Category 4). This coyote also pulled a M-44 from the top at 0 cm (Category 4).

We tested the fourth coyote with the M-44 at 17.8 cm. The coyote did not interact with the M-44. We applied a second lure after 5 hr. The second lure elicited rub-and-roll behavior in the coyote and the coyote triggered the M-44 with its back while rubbing and rolling against the device (Category 1). The coyote continued to interact with the M-44 and bit from the top (Category 3). We reset the M-44 with the initial lure at 15.2 cm. The coyote licked, rubbed, and marked on the M-44 (Category 2). The coyote bit from the top but did not pull or activate the M-44 (Category 3). The coyote also did not pull or activate the M-44 set at 0 cm (Category 1).

The fourth coyote pulled from the top at 15.2 cm but only bit from the top at 17.8 cm so we tested the fifth coyote with the M-44 at 15.2 cm. The coyote did not appear to interact with the M-44 for 48 hr (Category 1). The coyote did not interact or pull the M-44 at 0 cm (Category 1).

We tested the sixth coyote with the M-44 at 15.2 cm. The coyote bit at, but did not pull, the M-44 to activate it (Category 3). The coyote did not pull the M-44 at 0 cm (Category 1). In summary, 4 of 6 coyotes pulled a M-44 at a modified height. Two were able to pull a M-44 set at $<$30 cm, although $\geq$2 struggled with pulling from the top unless the device was set at 20.3 cm for a relatively tall coyote and 15.2 cm for the other coyote.

Captive Swift Fox Tests

We used 3 swift fox pens, with a pair of foxes in each, for testing between 13 and 19 November 2012. We could not identify foxes to individual based on camera-trap photos and video clips and we therefore describe results by each pen. We set M-44s in each pen at 15 cm. However, because of snowfall and snowpack, there were some days in which the height was less. We did not measure the height again to determine the new height with snowpack.

In pen 1, foxes interacted with the M-44 on 14 occasions. Neither fox pulled the M-44. Interactions included direct contact with the M-44 and licking or biting from the side. One interaction was undefined because it was blocked from camera view by the fox's body. On 6 occasions, photographs suggested 1 of 2 foxes tried to pull the M-44 but were unsuccessful (Category 3). Other interactions that we could define by camera-trap images included 3 that fit Category 1 and 4 that fit Category 2.

In pen 2, we observed foxes interacting with the M-44 on 9 occasions and successfully pulling the M-44 on the fifth occasion. These 5 occasions occurred on the first day. There was snowpack around the M-44 when it was pulled, suggesting the height was <15 cm (Fig. 2a). Although it was not possible to get an exact measurement of the change in height caused by snowfall, photographs suggest the height was reduced by about 2.5 cm. On the second occasion, a fox pulled from the side but on all other occasions licked or pulled from the top. Of those interactions that could be defined by camera-trap images, 1 was Category 1, 2 were Category 2, 5 were Category 3, and 1 was Category 4. We also detected a striped skunk (*Mephitis mephitis*) and black-billed magpie (*Pica hudsonia*) on camera-trap photographs.

Figure 2. Photographs of a (a) captive swift fox activating a modified M-44 (set at 15 cm) at the Cochrane Ecological Institute, near Cochrane, Alberta, Canada; and (b) wild coyote in North Dakota, USA, passing a modified M-44. Accumulating snowfall around the M-44 in photograph (a) likely lowered the height of the set to <15 cm.

In pen 3, foxes interacted with the M-44 on 6 occasions. On 2 occasions, the fox attempted to pull upward but was unsuccessful at activating the M-44 (i.e., Category 3). Two images were Category 1 and 2 other interactions were not definable. In summary, only 1 of 3 pairs of foxes was able to successfully pull a M-44 set at 15 cm, and it is likely that the device was <15 cm from ground level at the time it was pulled because of snowfall.

Field Trials

We placed M-44s in the field between 19 February and 14 April 2015. We set 31 M-44 stations, for an average of 27.1 (±0.8 SE) days/station. We used 1 modified M-44, ≥1 standard M-44, and 1 camera trap at each station. We set M-44s at 17.8 cm. We selected this height because light snow was forecasted and it would help ensure a minimum modified height of 15 cm. One camera was programmed improperly so no camera-trap data were available. Another camera was stolen during the field trials and a third camera was rubbed on and moved repeatedly by cattle (*Bos taurus*), so limited data were available from these 2 stations. We used 28 stations for results related to camera-trap photographs.

Photographs revealed M-44s were visited by coyotes, domestic dogs, white-tailed prairie dogs (*Cynomys leucurus*), striped skunks, raccoons (*Procyon lotor*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus canadensis*), cattle, horse (*Equus caballus*), red fox, lagomorphs (*Sylvilagus* sp.), small mammals, squirrel (Sciuridae), passerines (Passeriformes), turkey (*Meleagris gallopavo*), ring-necked pheasant (*Phasianus colchicus*), *Corvus* sp., bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), other raptors (Accipitridae), and North American porcupine (*Erethizon dorsatum*). We captured red foxes 1 time at one M-44 set and 10 times at another M-44 set. We did not capture any swift foxes interacting with M-44s.

Coyotes were photographed on 35 occasions at 25 of the 28 stations where cameras functioned properly (Fig. 2b). Coyotes were observed investigating, rubbing and rolling, and biting on the M-44 devices. On 2 events, we photographed coyotes marking the M-44s—once marking a modified set and once marking a standard set (Category 1). On 13 events, we obtained photographs of coyotes rubbing and rolling on M-44s (Category 1). Of these events, only 2 were at a modified M-44 and taken at the same set during the same night.

Coyotes activated 20 M-44s at 13 of the 31 stations (Category 4). Only 1 modified M-44 was activated (Category 4) and 1 modified M-44 was chewed on but not activated by a coyote (Category 3). All other activations were at standard M-44 sets of 0-cm height. We found no difference in the number of visits by coyotes at camera traps where coyotes did not activate any M-44, activated the standard M-44, or activated the modified height M-44 ($\chi^2_4 = 2.71$, $P = 0.61$). No other animal was reported to have pulled a M-44 on this study, although one standard M-44 not used as part of the study was pulled by a fox during the same time period. Notably, the red foxes photographed at 2 M-44 stations did not activate the standard or modified height M-44s.

DISCUSSION

M-44s have been modified to increase efficacy for fox removal in Australia by protecting the tops from debris or sandy soil (Busana et al. 1998, van Polanen Petel et al. 2004). Such modifications would be unlikely to reduce take by other, nontarget canids but illustrate how simple modifications are possible. In areas where swift foxes may occur, Wildlife Services Specialists are either not using M-44s or are setting M-44s at the highest tension and with gauze-and-wax top of 2.5–3.8-cm diameter to reduce risk of nontarget take of swift foxes (R. Krischke, personal communication). Swift foxes are smaller than coyotes; therefore, a modification to adjust the height at which the M-44s are set was attempted to prevent swift foxes from being able to successfully pull from above and consume the sodium cyanide if they interacted with a M-44. Although other modifications are likely possible, a height modification was easy for Specialists to do themselves and did not affect the integrity of the device.

Although the sample size was small, results of this study suggest a modified height may reduce the ability of a swift fox to pull a M-44 but also reduces activation rates by coyotes. Four captive coyotes were able to activate M-44s set at 15–17 cm. The 2 captive coyotes that did not activate modified M-44s also did not activate the M-44 at the standard setting, suggesting the lack of activation was unrelated to modifications and likely related to behavioral profiles of those coyotes (Young et al. 2015). In 2 of 3 swift fox pens, 15 cm was sufficient height to prevent successful activations of M-44s. Despite repeated interactions with the M-44, the devices were not activated. Camera-trap photos from the third pen suggested the modified height was <15 cm because of snowpack at the time the device was activated. Unfortunately, the height of the M-44 at its removal was not measured to confirm this deviation, but photographic evidence suggested it was closer to 13.5 cm in height. Snowfall is likely in much of the range of the swift fox; therefore, Specialists were given a range of heights for which to set the M-44s during field trails, with 15 cm being the lowest height. This allowed Specialists to set the device higher if snowfall was expected during the trials to ensure the minimum height was 15 cm.

During field trials in North Dakota, not all M-44 stations were visited by coyotes or other canids, and more coyotes visited and investigated M-44 stations than activated M-44s. Although alpha coyotes may be more likely to abandon investigations before they are close enough to be photographed because of their wariness of camera traps (Séquin et al. 2003), activation rates for M-44s placed with camera traps compared with those without camera traps did not differ in a M-44 study in West Virginia and Virginia, USA (Shivik et al. 2014). In that study, coyotes pulled 17 and 19 M-44s set with and without camera traps, respectively (Shivik et al. 2014). Similarly, most photographs of coyotes at M-44s during this study did not show coyotes looking at the cameras but instead showed them interacting with the M-44 devices or nearby objects and lures. It is likely that some coyotes are more likely to avoid M-44s than others, much like what was observed with captive coyotes in this study and with other novel objects (Mettler and Shivik 2007).

The difference in the number of modified M-44s that were activated when compared with standard M-44 sets suggests stronger avoidance of modified M-44s that could significantly reduce the efficacy of M-44s in areas where they are used to remove coyotes. Managers should continue to use M-44s set at ground level in areas where there is relatively low or no risk to nontarget, smaller canids such as the swift fox. In areas where other threatened or listed small canids such as the swift fox occur, our results suggest managers could modify M-44 height to 15–18 cm for coyote control to reduce risk of nontarget take. M-44s may not be as time-effective as other removal techniques (van Polanen Petel et al. 2004), so such a modification is not practical or efficient in areas with little or no risk to nontarget canids. However, we tested only a small sample of captive foxes and additional testing in an area where swift foxes are common and more likely to interact with the modified M-44s are still needed.

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