2014

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Wildlife Society Bulletin 38(1):217–220; 2014; DOI: 10.1002/wsb.361

Tools and Technology

Animal Attendance at M-44 Sodium Cyanide Ejector Sites for Coyotes

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ABSTRACT Sodium cyanide (NaCN) ejectors for coyotes (*Canis latrans*), known as M-44s, are used in many parts of the United States for lethally removing coyotes to protect livestock or other resources. Quantifying selectivity of current devices in killing target and non-target species is important to users and provides a baseline for future development of more effective and selective techniques. We used motion-activated cameras to monitor M-44 locations for coyote and other species visitations to the sites. Because camera presence potentially influences coyote behavior, we first compared activation of M-44s at paired sites where cameras were and were not present. Coyotes activated M-44s sites with cameras ($n = 17$) similarly to sites without cameras ($n = 19$). During 832 site-days of observation, coyotes visited M-44 sites 29 times, and 18 other species visited 1,597 times. The mean visitation ratio for non-coyotes to coyotes was 2.8:1 at the M-44 locations monitored ($n = 22$). Non-coyotes were much less likely to touch the devices with their noses or mouths than were coyotes (0.24:1). No non-canid activated an M-44, suggesting very high selectivity toward killing canid species. Published 2013. This article is a U.S. Government work and is in the public domain in the USA.

KEY WORDS camera, *Canis latrans*, coyote, M-44, selectivity, Virginia, West Virginia.

Sodium cyanide (NaCN) ejectors, in various forms, have been used to manage predator damage since the 1930s (Blom and Connolly 2003). The M-44 is a spring-powered device designed to be staked into the ground. When the top of the device is baited with a lure, the device can induce a bite-and-pull response from canids, usually coyotes (*Canis latrans*). When the device is activated, NaCN powder is propelled upward and into the mouth of the animal, resulting in the animal's death (Connolly and Simmons 1984).

Understanding coyote behavior and response to management methods such as the M-44 is particularly important for development of improved methods (Shivik 2006, Darrow and Shivik 2009). Recent efforts have examined how scent marks and lures influence coyote movements (Shivik et al. 2011, Wilson et al. 2011). Technological improvements, including remote camera equipment, have improved behavioral observations on wild coyotes (Peterson and Thomas 1998, Shivik and Gruver 2002) and many other species (Rice et al. 1995, Kristan et al. 1996, Stewart et al. 1997, Delaney et al. 1998, Davis et al. 1999). A potential for bias exists when using cameras, however, because some coyotes were reported to be wary and to avoid camera sites (Sequin et al. 2003). Therefore, we devised an experimental study to determine whether M-44 devices with and without camera monitors were differentially activated by coyotes.

The second objective of our study was to measure the relative abundance and focused activities of coyote, other canid, and non-target animals at M-44 placement sites in Virginia and West Virginia, USA. This objective resulted from proposals to limit the use of management tools in response to perceptions of non-selectivity in some areas of the United States (Cockrell 1999, Blom and Connolly 2003) and increasing conflicts with coyotes in eastern North America. Selectivity of methods, especially lethal ones such as M-44s, is a primary concern in wildlife management, but selectivity can have several definitions and components (Shivik and Gruver 2002). One measure of overall selectivity is the number of target animals captured or killed relative to the total number of animals, including non-targets, captured or killed. Such a definition of overall selectivity is problematic because it does not account for the abundance and activity of target animals in the area relative to non-target animals. Additionally, it does not account for the relative attractiveness of the lure or bait system to target and non-target species or the mechanical aspects of a capture or kill system that would exclude non-targets because of

Received: 7 February 2013; Accepted: 2 July 2013
Published: 19 November 2013

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morphological or behavioral differences between species (Shivik and Gruver 2002). A more appropriate measure of selectivity evaluates the number of target animals relative to the number of non-target animals that are 1) exposed to the capture or kill system, and 2) attracted to and investigate the system.

STUDY AREA AND METHODS

This study was conducted in Botetourt, Floyd, Pittsylvania, Rockingham, and Wythe counties in Virginia; and Calhoun, Jackson, Kanawha, Mason, Mercer, and Pocahontas counties in West Virginia. These counties lay in the Piedmont, Blue Ridge, Ridge and Valley, and Appalachian Plateau physiographic regions (Fenneman 1938, Fleming et al. 2012). The Piedmont Plateau was characterized as a rolling hilly landscape with elevations of 50–300 m and a patchwork of second-growth oak (*Quercus* spp.)–hickory (*Carya* spp.) forest (Fleming et al. 2012). The Blue Ridge was a weathered set of peaks and a rolling plateau 1,288–1,746 m in elevation, which was dominated by oak–hickory forest (Fleming et al. 2012). The Ridge and Valley was a long parallel series of ridges with elevations of 1,200–1,400 m and valleys at elevations <900 m (Fleming et al. 2012) dominated by a mixed-oak forest (Strausbaugh and Core 1978). The Appalachian Plateau was a large plateau, which had been eroded into a system of hollows and valleys and was dominated by mixed hardwoods (Strausbaugh and Core 1978).

The study was conducted on randomly chosen properties that were already receiving livestock protection services from U.S. Department of Agriculture Animal and Plant Health Inspection Service Wildlife Services. Animals protected were cows, calves, sheep, lambs, goats, and kids. Foxes (*Vulpes vulpes*), feral dogs, and coyotes were targeted using a variety of canid-call lure types. Applicators in this study set M-44s using a variety of canid call lures as they would for normal operations and followed 26 administrative use restrictions designed to minimize non-target take (Slate et al. 1992, United States Department of Agriculture 2010).

We deployed Reconyx RapidFire RC 60 digital infrared trail cameras (RECONYX, Inc., Holmen, WI) at 24 M-44 device locations from February to September of 2010 and 2011 and February to May of 2012. The camouflage print cameras were mounted to trees or other pre-existing anchor sites with black-and-green colored bungee cords and cable locks. Cameras were located 4–15.5 m from devices where an appropriate tree for mounting was found, and were installed 0.5–2 m from the ground. Cameras were programmed to record 3 images/trigger in 1-second intervals 24 hours/day; these images were stored on a 2-gigabyte memory card. The cameras and M-44s were checked weekly.

To determine whether the presence of cameras influenced coyote activation of M-44s, we paired M-44s with cameras to M-44s without cameras (reference M-44s) on the same property. Reference M-44s were 102–1,715 m from M-44 sites with cameras. We recorded the number of M-44 activations at each camera and reference site. To determine whether cameras appeared to bias coyote willingness to approach and trigger M-44s, we conducted paired *t*-tests to compare the mean number of M-44s triggered by coyotes between treatment (with camera) and control (without camera) sites.

To measure selectivity of M-44s, we examined images from each camera site and recorded the number of animals visiting sites. We calculated the visitation rate as the number of times individuals of each species were within 1 m of the device over the number of days the camera was monitoring the sites. We calculated the investigation rate using the number of times each individual of a species was observed making oral or nasal contact with an M-44. Animals coming within 1 m of a device were only counted once no matter how long they remained there, and events were categorized either as a visitation or an investigation and not both. Additional visits were not counted unless 30 minutes elapsed between pictures taken. The sites were the sample units for all analyses. That is, visitation rates were measured at each site and the mean was calculated based on the number of sites.

We calculated the relative visitation rate for each species by dividing its visitation rate by that for coyotes. A relative visitation rate >1 indicated that the species was more likely to visit an M-44 than were coyotes. We also calculated the relative investigation rate for each species by dividing investigation rate by that for coyotes. A relative device-investigation rate >1 indicated that the species was more likely than coyotes to approach and make oral or nasal contact with the M-44. Because this portion of the study was observational and not experimental, analyses were limited to descriptive statistics and rates were evaluated using means and standard errors. Finally, we recorded the number of coyotes that were killed by the M-44s relative to visitation and investigation rates.

RESULTS

In the experiment examining camera-monitored versus no-camera M-44 sites, we monitored 24 camera and 24 no-camera stations for 1,673 site days. M-44s were triggered 39 times by identifiable species; 36 times by coyotes, 2 times by domestic dogs, and 1 time by a red fox (*V. vulpes*), all of which were targeted species for control. There was little evidence that coyotes were more wary and acted differently at M-44 sites with cameras, because coyotes triggered M-44s with cameras a similar number of times ($n = 17$) compared with reference sites without cameras ($n = 19$; $P = 0.66$; $t = 0.44$, df $= 23$).

In the observational study examining visitation and investigation rates at camera-monitored M44 sites, we identified 19 different species visiting at 22 active and functioning camera stations (camera failures occurred when batteries or hardware malfunctioned or mounts slipped) during 832 site-days of observation. Coyotes were recorded visiting M-44 sites on 34 occasions and investigating them on 11 occasions. There were 18 other species that visited the sites 1,597 times and investigated on 55 occasions. Black bear (*Ursus americanus*), bobcat (*Lynx rufus*), domestic cat, domestic cow, crow (*Corvus* spp.), white-tailed deer (*Odocoileus virginianus*), domestic dog, donkey, red fox,

Table 1. Animal visitation to M-44 sites based on 832 days of observation at 22 locations in Virginia and West Virginia, USA, 2010–2012.

Species	Visitation rate[a]	SE	Investigation rate[b]	SE	Relative visitation rate[c]	Relative investigation rate[d]
Bear	0.001	0.001	0.000	0.000	0.037	0.000
Bobcat	0.005	0.003	0.000	0.000	0.116	0.000
Cat	0.002	0.002	0.000	0.000	0.044	0.000
Cow	0.401	0.135	0.019	0.007	10.072	1.119
Coyote	0.040	0.018	0.017	0.008	1.000	1.000
Crow	0.015	0.008	0.000	0.000	0.380	<0.000
Deer	0.177	0.064	0.009	0.005	4.434	0.526
Dog	0.012	0.008	0.012	0.007	0.301	0.725
Donkey	0.002	0.002	0.001	0.001	0.058	0.050
Fox	0.003	0.002	0.000	0.000	0.084	0.000
Horse	0.001	0.001	0.000	0.000	0.022	0.000
Opossum	0.011	0.007	0.002	0.002	0.269	0.108
Passerine	0.042	0.029	0.000	0.000	1.043	0.000
Rabbit	0.002	0.001	0.000	0.000	0.046	0.000
Raccoon	0.063	0.045	0.008	0.005	1.574	0.443
Sheep	1.171	0.846	0.012	0.009	29.392	0.699
Skunk	0.001	0.001	0.000	0.000	0.022	0.000
Squirrel	0.021	0.009	0.004	0.004	0.537	0.258
Turkey	0.082	0.032	0.003	0.003	2.06	0.155

[a] Visitation rate = mean visits (within 1 m of the M-44) per day observed at 22 monitored sites.
[b] Investigation rate = mean potential activations (contacting the M-44 with nose or mouth) per day observed at 22 monitored sites.
[c] Relative visitation rate = area rate for each species divided by the area rate for coyote.
[d] Relative investigation rate = potential rate for each species divided by the potential rate for coyote.

domestic horse, opossum (*Didelphis virginiana*), passerines (Passeriformes), rabbit (*Sylvilagus* spp.), raccoon (*Procyon lotor*), domestic sheep, skunk (Mephitidae), squirrel (Sciuridae), and turkey (*Meleagris gallopavo*) visited M-44 sites (Table 1).

Non-coyote species most seen were cows ($n = 378$ observations), sheep ($n = 925$), deer ($n = 114$), and turkey ($n = 63$); all other species were seen on <22 occasions each. Of the 18 non-coyote species documented visiting the M-44 sites, 6 were more common than coyotes (turkey, sheep, raccoon, passerine, deer, cow), and the remaining 12 were less common. The mean ratio of non-coyote:coyote visitation rates was 2.8:1.Only domestic cows were more likely to investigate the device than coyotes. The mean ratio of non-coyote:coyote investigation was 0.24:1.

DISCUSSION

Although some amount of intrusion occurs, coyote territoriality may provide an initial element of selectivity toward certain animals in certain places (Shivik et al. 1996). We did not identify the spatial structure of coyote territories, however, or know the social status of coyotes that visited M-44 sites, but cameras did not appear to repel coyotes from M-44 locations, in contrast to previous reports (Sequin et al. 2003). Our results were more in line with Billodeaux and Armstrong (2005), who concluded that coyotes showed no avoidance of camera stations. Sequin et al. (2003) reported that coyotes in California, USA, observed researchers installing cameras from a distance and that coyotes subsequently avoided those locations. It is possible that the more lush vegetation in the mountains of the eastern United States prevented coyotes from observing humans. Also, M-44s use a lure on the top of the device to attract coyotes. Sequin et al. (2003) did not use lures with their cameras, and it is possible that coyotes will overcome initial wariness or neophobia if a sufficiently attractive stimulus is present (Shivik et al. 2011). Perhaps the most likely reason for the difference between our results and those of Sequin et al. (2003) was that our cameras were all located 4–15.5 m from attractants, while Sequin et al. (2003) had equipment much closer, all <5 m from the trails. It is likely that older animals may be more wary in such situations, but if cameras are placed further away from attractants, they will not influence coyote behaviors around trap or M-44 sites.

Phillips and Gruver (1996), searched trap sites for tracks and sign in Texas, USA, and reported that 826 non-target individual animals and 902 coyotes visited trap sites, which was similar to our results in that many other species are likely to encounter devices intended to capture or kill coyotes. Our results were also similar to Phillips and Gruver (1996) in that all non-canid species were excluded from capture because of behavioral tendencies of non-targets coupled with mechanical aspects of the capture devices. M-44s, for example, rely on an animal to pull on the top of the device with its mouth, which is a canid-typical behavior. Shivik and Gruver (2002) used video cameras in Texas to conclude that non-target species were 16 times more likely to enter trap-site areas than coyotes, but that non-target species were much less likely to investigate lures and traps and be captured. Mean relative visitation rate reported for live capture traps was 3.5:1 for non-target:dingo (*C. familiaris dingo*) in Australia (Newsome et al. 1983). Our study examined a different attractant system and was performed in different habitats than other work, and it augmented previous observations regarding differential selectivity of management methods for coyotes (Shivik and Gruver 2002, Wilson et al. 2011). Specifically, many other species are more likely to visit capture or kill systems for coyotes, but non-target species are much less likely to approach and investigate the attractants and engage the devices than coyotes.

For lethal methods such as M-44s, selectivity is particularly important. When animals are captured in a live trap, it is often possible to release non-target species unharmed. If an animal uses its mouth to pull and activate an M-44, however, the most likely result is immediate death. The selectivity of M-44s may therefore be more important than that of live-capture devices. Our data indicate that M-44s have a high degree of selectivity. Only one other species was equally or more likely than coyotes to use their mouths and noses to investigate the device than coyotes: domestic cows. The relatively high abundance of domestic animals in our study was to be expected because M-44s were set in areas where livestock required protection. However, because cows do not grab and pull on M-44s as canids do, they are not susceptible to them.

We concluded that M-44s, as deployed in this study, were very selective for coyotes. Other species that visit the sites were not further attracted to the M-44 devices. Furthermore, the canid-specific behavior required to activate the device (biting and pulling) provides a second element of selectivity for M-44s. No non-target species triggered the devices. Too few foxes or domestic dogs visited devices to make strong inference about inter-canid selectivity, but because of behavioral similarities between coyotes, domestic dogs, foxes, and wolves, we assume that M-44s are not selective for coyotes compared with other canid species. Development of coyote-specific lures would further improve selectivity of the device (Kimball et al. 2000).

ACKNOWLEDGMENTS

We thank the wildlife specialists of the Virginia and West Virginia programs for their efforts in the field, which were essential and instrumental in conducting this study. Logistical and other support was provided by S. Barras, C. Croson, and J. Houben. All work was performed following approval by the National Wildlife Research Center's Institutional Animal Care and Use Committee under QA-1640.

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Associate Editor: Boertje.