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Efficacy of Ropel® as a coyote repellent

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Abstract: We examined the repellency of a commercially available animal repellent to determine the efficacy of its application to objects that are attractive to coyotes (*Canis latrans*). Specifically, we aimed to both prevent chewing behavior by coyotes on a nylon-like strapping material, which is used to construct barrier-arresting systems on military airstrips, and determine the ability of the solution to prevent the animals from repeating the undesired behavior. We mixed Ropel® Animal and Rodent Repellent with a liquid latex sticker to form a 2% latex and 98% Ropel solution. We used a 2% latex and 98% water solution as a control. The solutions were applied to test material placed in coyote pens. We exposed 12 mated pairs of coyotes to the Ropel and control in a 2-choice test and recorded behavior toward the materials using camera traps. Photographs and the condition of the material were used to determine when, and if, individual coyotes approached, made contact with, tasted, repeatedly tasted, or destroyed the material. There was no difference between the number of treatment and control materials tasted, but significantly more control materials were repeatedly tasted than treatment materials. However, there was no difference between the number of treatment and control materials destroyed. While results suggest that there are some repellent properties in the Ropel solution after initial tasting, we do not recommend this product be relied upon as a coyote-specific repellent.

Key words: aviation, *Canis latrans,* human–wildlife conflicts, repellent, taste avoidance

Coyotes (*Canis latrans*) are known to chew and bite nonfood items, such as drip irrigation system materials (Werner et al. 1997). Coyote chewing behavior causes costly destruction of such materials and may cause human hazards. For example, chewed pieces of material used to create a barrier-arresting system (Figure 1) at military airports may compromise the integrity of the device and, therefore, its ability to adequately and safely halt aircraft. This could damage or destroy the aircraft and surrounding structures and can lead to injury or death to airfield personnel. Such damage has already been reported at a military airport in Texas, and it is likely occurring at other bases. This study was developed to investigate a repellent that may reduce this problem.

Repellents can be chemical, visual, acoustic, or a combination of these characteristics (Mason and Otis 1990). Many studies have been conducted on birds and mammals to determine the effectiveness of such repellents. Certain types of chemical repellents have shown promise, such as sensory irritants (Rozin et al. 1979), semiochemical imitations (Mason 1998), and gastrointestinal irritants (El Hani and Conover 1995). Sensory irritants are substances that affect the smell or taste of the target species. Capsaicin, the "hot" element in hot sauces, is a chemical irritant for most mammals (Rozin et al. 1979). Semiochemicals are used as signals between individual animals, such as pheromones and allomones. Some repellents provoke gastrointestinal irritation and are typically considered indirect repellents, because the animals learn to avoid the taste, which they associate with their sickness. Lithium chloride was tested as a method of conditioned food aversion by stimulating gastrointestinal irritation in coyotes preying on sheep (Gustavson et al. 1974). Of these 3 products, the sensory irritants are the most effective across tested species, because they cause immediate avoidance (Mason 1998).

Studies have tested sensory irritants on a wide breadth of animals, including birds (Norman et al. 1992, Mason and Otis 1990), elk (*Cervus elaphus*; Andelt et al. 1994), deer (*Odocoileus* spp.; Curtis and Boulanger 2010, Ward and Willaims 2010), and coyotes (Burns and Connolly 1980, Werner et al. 1997, Hoover and Conover 1998, Zemlicka and Mason 2000). Coyotes often are the focus of sensory irritant tests because they are one of the most common and successful predators in North America (Knowlton et al. 1999). While several repellents have been tested, few show effectiveness against coyotes (Burns et al. 1984, Mason and McConnell 1997, Zemlicka and Mason 2000).

Many studies that failed to identify a repellent that is effective for preventing acts of depredation likely failed because depredation involves a variety of motivations beyond that of consuming prey (Knowlton et al. 1999). Trials that investigated repellent properties of Renardine® showed the solution to be ineffective at repelling coyotes from a small area that contained a food source (Zemlicka and Mason 2000). Hunger possibly was a motivating factor that compelled the coyotes to interact with the repellent. Burns et al. (1984) used sublethal doses of 10 different toxicants in livestock-protection collars on live sheep that were put into captive coyote pens. None of the 10 toxicants abated or prevented future attacks on livestock by coyotes previously exposed to the toxicants. These studies tested the capability of repellents to prevent coyotes from interacting with a food reward, which is likely more challenging than when a nonfood reward is at stake.

There is evidence that capsaicin, lithium chloride, pulegone, and cinnemaldehyde are potentially effective taste repellents for coyotes when applied directly to inanimate or immobile objects, such as irrigation hose and eggs (Hoover and Conover 1998, Werner et al. 1997). Capsaicin, lithium chloride, and pulegone all were tested in investigations to identify a repellent for use on irrigation hose (Werner 1997). Chewing behavior was measured in 2-choice tests in pre-treatment, treatment, and post-treatment phases. Results from this study showed a decrease in chewing behavior from the pre-treatment to treatment phase, and a return to pre-treatment levels in the post-treatment phase, indicating that the coyotes avoided repellents and not irrigation hose.

Figure 1. BAK-15 Barrier Arresting System as it lies ready for deployment on a military airstrip.

Ropel Animal and Rodent Repellent is a nontoxic, commercially available repellent from Nixalite®. It is marketed as a pest repellent, listing denatonium saccharide and thymol as the active ingredients. Denatonium saccharide has been investigated with mixed reviews as a repellent, based on its bitterness; rodents have been shown to both avoid (Langley et al. 1987) and prefer (Davis et al. 1987) the compound. It operates via taste avoidance due to its extreme bitterness. While previous tests of Ropel failed to repel other species (Swihart and Conover 1990, Andelt et al. 1994, Woolhouse and Morgan 1995, Witmer et al. 1997, Wagner and Nolte 2001), there are no studies reporting the efficacy of the repellent for carnivores, even though anecdotal evidence from domestic dogs suggests that Ropel may be effective. Preliminary tests also suggest that Ropel can be applied without degrading the material needing protection. We hypothesized that the repellent will adhere to our test material and deter coyotes from chewing on the material.

Methods

The study was conducted at the USDA National Wildlife Research Center's Predator Research Facility in Millville, Utah, USA. Approximately 100 adult captive coyotes are housed as mated pairs at the facility to better reflect social structure observed in the wild. We used 12 mated pairs for this study, housed in pie or pack pens throughout the length of the

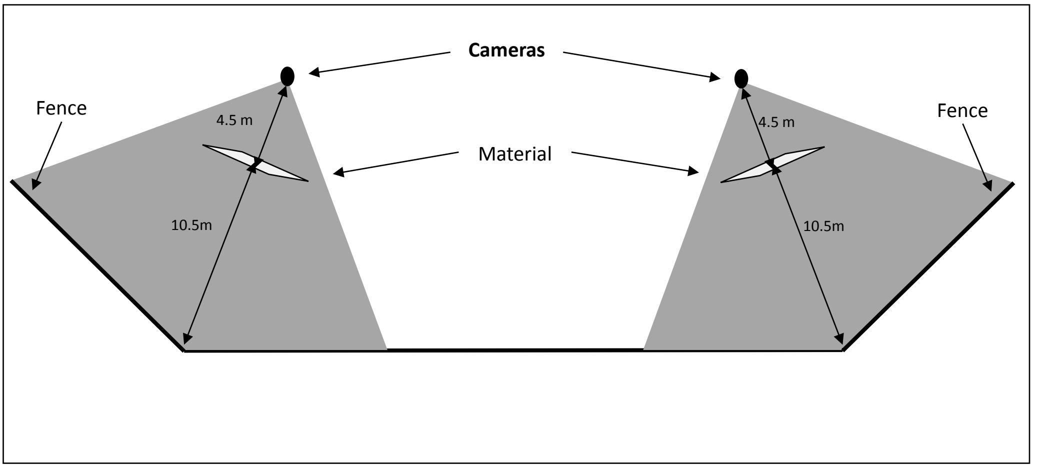

Figure 2. Detailed schematic of cameras and materials placed in one of 2 types of 0.65-ha pens with captive coyotes. The shaded area indicates the range of the camera.

study. Pens are approximately 0.65 ha. Four pie pens are triangular in shape and create a half circle. Test materials were placed in the large side of the triangle. The 8 pack-pens are octagonally shaped. All of the pens are separated from neighboring pens, with ≤3 m between boundary fence lines. Paired coyotes were housed in the pens ≤3 weeks prior to testing so that they were acclimated to their pen during testing. Coyote pairs were selected from a pool of bold individuals to facilitate interaction with the material; it is likely that the offending wild coyotes are bold individuals because they repeatedly approach objects in areas of high human activity. Boldness was categorized as a binary response variable based on whether or not a coyote interacted with novel objects presented to them previously.

We designed a 2-choice test to test for differences in the destructive chewing behavior of coyotes toward Ropel-treated and untreated material. We used nylon strapping, 3 cm wide and 3 mm thick as testing material. We secured a longer, taut piece of material at both ends by different stakes and folded shorter pieces over each other in a pile of loops secured at both ends to the same stake (Figure 1). Thus, each test item presented to the coyotes was composed of a 1-m-long strip and 3, 0.2-m loops.

For each pen, 2 identical segments of material were installed (Figure 2). Latex stickers were added to the control and treatment solutions at a 2% concentration to aid in adhesion of the liquids to the materials. The treatment solution was the commercially available Ropel to which the latex sticker was added. The control solution was mixed from the latex sticker and water. Both solutions were applied twice before the beginning of the study, as per the manufacturer's instructions: once 4 days prior to installation and a second time on the day before installation of the test pieces in the pens.

The test materials were installed in the pens so that they would not interfere with the gates or watering systems and were equidistant from each of these pen features. This avoided unintentional interactions or incidentally encouraging interactions with the material while coyotes were approaching food or water placed near gates. During the study, coyotes were fed using the door farthest from the test site.

Motion-activated trail cameras were used to monitor coyote behavior. An infrared camera was mounted in front of both the treated and control material. The cameras were installed in the pens 1 week before the beginning of the study so that the coyotes could habituate to them prior to the introduction of material. Photographs taken during that week were reviewed to ensure proper camera angles and heights. Cameras were attached to metal t-posts 50 cm from the ground. Posts were placed in 2 consecutive corners of each test pen, and 15 m from the fence inside the pen (Figure 2). Cameras were set up to take 3 consecutive pictures with 30-second intervals between events, and they remained on throughout the

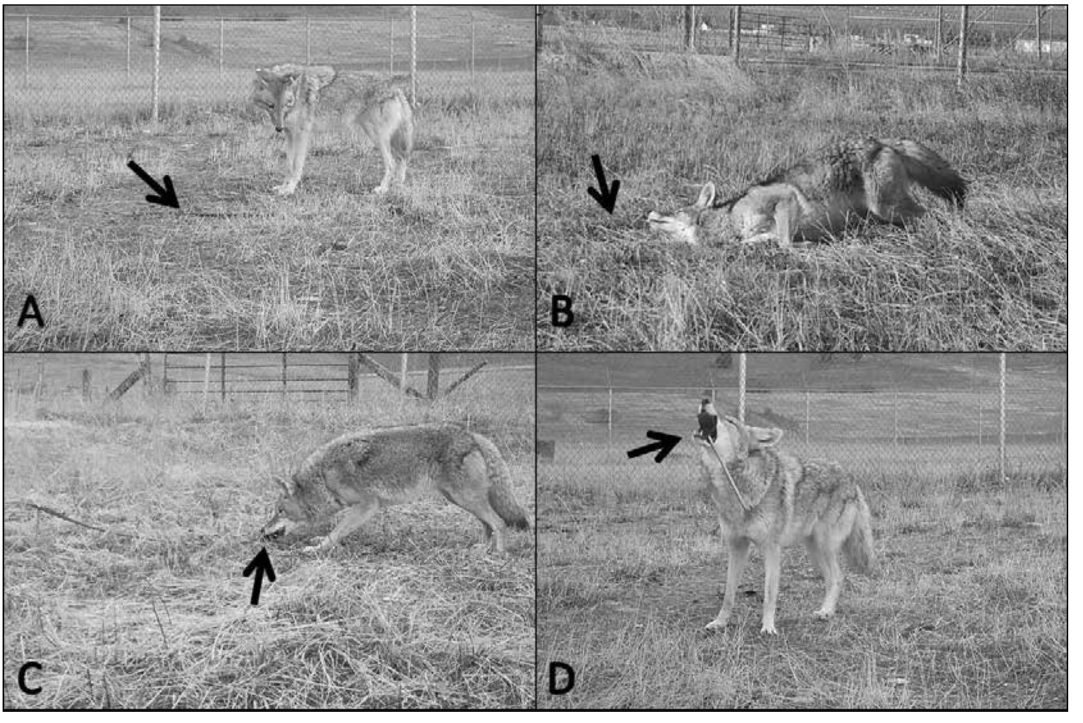

Figure 3. Example of photos classified as (A) approach, (B) contact, (C) taste and repeated taste, and (D) destruction. Black arrows point to the location of material.

experiment, allowing us to better classify each interaction.

After the experiment, all cameras were retrieved and pictures were analyzed to classify coyote behaviors toward the material. The coyotes were recognized individually on pictures using unique identifiers, such as number and color of ear tags and pelage differences. The data were analyzed by individual coyotes rather than by pairs.

The cameras recorded time and date of each photograph, enabling a time-related analysis of coyote behaviors. For each coyote, the time to approach the material, contact it, taste it, taste a subsequent time (hereafter, repeated taste), and destroy the material were noted. We considered approach as any investigatory behavior toward the material without contact. This included walking by the material and looking at it, stopping near the material, sniffing from afar, searching in the grass for material, and circling around the material (Figure 3). Contact was defined as any action where the coyote touched the material with body parts other than the mouth and tongue. This included pawing, rolling on material, and sitting or lying on material. Taste was defined as any oral contact, including the material in the mouth of the coyote, licking, chewing, or adjusting the material with the mouth. Repeated taste included any time the coyote was seen making oral contact with the material after the initial taste requirement was met. Destruction occurred when the integrity of the material was compromised; this included any fraying, severing, ingestion, or moving of the material from its original position. We also differentiated between "not applicable (NA)" and "unknown." Not applicable was applied to instances in which we had no way to infer that the animal completed the action. For example, if we captured a coyote approaching material, but failed to capture any further interactions, then we would record NA for all subsequent behavior classifications. Unknown indicated an action not observed through pictures for individuals that were observed doing subsequently classified behaviors. For example, if we saw a coyote tasting material that we had yet to capture approaching the material, then we marked approach as unknown. Although we knew that the coyote approached the material,

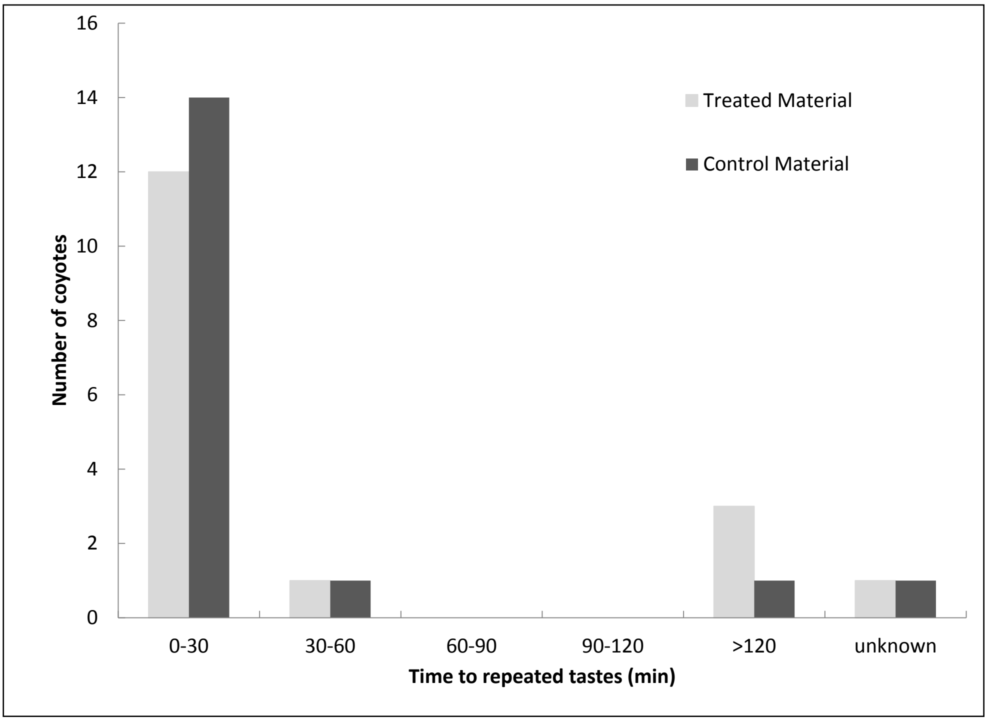

Figure 4. Time from initial taste to repeated taste of treated and control materials by coyotes when repeated taste occurred ($n_{treatment}$= 16, $n_{control}$= 17).

we did not capture the time of approach. We collapsed our classifications into did not taste, tasted once, and tasted repeatedly. We intended to observe coyotes with materials for ≤28 days.

Three chi-squared tests were run, with significance level set at P = 0.05. We first determined if coyotes were more likely to taste control or test materials. For the next 2 analyses, we excluded coyotes that did not initially taste the materials. We compared how many coyotes repeatedly tasted treatment versus control materials. Finally, we compared the number of treatment versus control materials destroyed by coyotes. All methods were approved by USDA-National Wildlife Research Centee Institute for Animal Care and Use Committee (QA-2167).

Results

The study was terminated after the first daily check, which occurred approximately 24 hours after the segments of material were installed. Within these first 24 hours, coyotes in ten of 12 pens shredded the material into ingestible pieces and cached the stakes. This presented a hazard to the safety and health of the animals.

In seven out of 12 pens, both the treated and the control items were completely destroyed within the first 12 hours. In 2 pens, only the treated pieces were destroyed, while in 1 pen, only the control was destroyed. In the remaining 2 pens, neither the treatment nor control was destroyed by the coyotes. This left 7 coyotes (3 treated coyotes and 4 untreated, control coyotes) of 24 test materials intact at the time of the first daily check. Destruction of the material suggested that repeated tastes had occurred, and this was later corroborated by photos.

All but 1 male coyote (96%) interacted with both materials. Twenty-two of 24 coyotes tasted the treatment material, while 17 coyotes repeatedly tasted (Table 1). Seventeen of 24 coyotes tasted the control material, of which all 17 animals repeatedly tasted (Table 1).

Most of repeated taste events occurred within the first 30 minutes following the initial taste for both the control and treatment materials (Figure 4). No repeated taste occurred between 60 and 120 minutes following initial taste, and only 1 control (tasted by a male) and 3 treatments (tasted by 2 females and 1 coyote of unknown sex) were repeatedly tasted after 2 hours.

Table 1. Percentage of male (n = 12) and female (n = 12) coyotes that demonstrated approach, contact, taste, repeated taste, and destruction behaviors toward material treated with and without Ropel®.

Material type	Sex	Approach	Contact	Taste	Repeated taste	Destroy
Treated	M	100	92	92	75	75
Treated	F	100	92	92	67	58
Control	M	92	75	67	58	58
Control	F	100	92	83	83	83

There was no significant difference between the number of treatment and control materials tasted (χ^2 = 2.22, P = 0.14), and the control was repeatedly tasted more than the treatment (χ^2 = 4.45, P = 0.04). Considering only the individuals that repeatedly tasted, there was no difference between the number of treatment and control materials that were destroyed by coyotes (χ^2 = 1.13, P = 0.29).

Discussion

Based on our findings, we do not recommend the use of Ropel as a coyote repellent for barrier-arresting systems or other critical equipment. Even though statistically fewer coyotes repeatedly tasted the test material, coyotes that did so were able to destroy it. There was significant damage to test materials in <24 hours, and treated materials were totally destroyed more often than were control materials.

Our results suggest that Ropel-treated material may initially attract coyotes to a material but result in future avoidance. These results are not surprising, because the repellent operates via taste avoidance, in which target animals must taste the repellent at least once for it to be effective. Initial attraction was indicated by more interactions with the treated than with the control materials during our 2-choice taste test, while learned avoidance was indicated by a reduction in repeated taste of the treatment materials but not the control materials.

Werner et al. (1997) also presented a 2-choice test that resulted in decreased interaction with test materials. Unlike in our study, coyotes did not discriminate between treated and untreated test materials during the treatment phase, and they reduced chewing on both. This difference may be related to housing of the captive coyotes. In our study, test materials were 50 m apart, a distance at which coyotes could easily discriminate odors, whereas in Werner et al.'s (1997) study, the test materials were side by side within a kennel. The reduction in chewing behavior witnessed in the Werner et al. (1997) study also reduced damage incurred to the material by 40%. We witnessed complete destruction of our test material, with no discrimination between treatment and control, even when repeated tastes decreased.

Management implications

Our study was conducted in part to aid a real problem occurring at military airports. The coyotes at the airport already are interacting with the material. Identifying a repellent to stop this and similar chewing behaviors in wild coyotes will be much like preventing a captive coyote from chewing on a novel object. Thus, we believe that our results are translatable to wild coyotes, although there may be differences in the rate at which material is destroyed. Differences in the rate of destruction would likely stem from the fact that captive coyotes engage in more pathological and repetitive behaviors (Shivik et al. 2009). Thus, although coyotes showed some taste avoidance to materials treated with Ropel, the damage incurred to test materials suggests that it should not be relied upon as a coyote repellent.

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