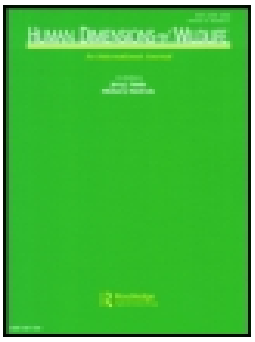

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NOTE

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Efficacy of motion-activated sprinklers as a humane deterrent for urban coyotes

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ABSTRACT
Non-lethal management methods for urban coyotes are limited despite an increase in human-coyote conflicts in North American cities. Deterrent devices are recommended to reduce human-coyote conflict; however, no scientific studies have assessed the efficacy of deterrents with urban coyotes. This article investigated the short-term efficacy of motion-activated sprinklers for deterring urban coyotes from residential areas in the Metro Vancouver Regional District of British Columbia. Camera traps were used to monitor coyote activity over three consecutive phases: pre-deterrent, deterrent, and post-deterrent. Sprinklers significantly reduced the daily mean number of coyote visits during the deterrent phase compared to the pre-deterrent phase. There were no significant differences in the daily mean number of coyote visits between the pre-deterrent and post-deterrent phases, however mean duration of visits significantly decreased. This article offers evidence that sprinklers may reduce the presence of coyotes in residential areas, thereby encouraging future research into the development and implementation of humane deterrents for urban coyotes.

KEYWORDS
Canis latrans; human-wildlife conflict; humane deterrent; urban wildlife

Introduction

Coyotes (*Canis latrans*) are found in most metropolitan cities across North America (Gompper, 2002; White & Gehrt, 2009) living in close proximity to humans while posing minimal risks to human health and safety. However, human-coyote conflicts do occur (Lukasik & Alexander, 2011; Poessel et al., 2013), and over the last two decades there has been an increase in reported human-coyote conflicts (Timm et al., 2004; White & Gehrt, 2009). Human-coyote conflicts can include real conflicts such as aggressive interactions with humans or pets that have the potential to result in injury (Poessel et al., 2013), as well as perceived conflicts where coyote sightings or vocalizations themselves are viewed as conflict (Draheim et al., 2013). Consequently, the presence of coyotes in residential areas can elicit public concern due to the perception that coyotes are dangerous to children and pets (Elliot et al., 2016; Sponarski et al., 2016).

Traditionally, carnivore populations in rural environments have been managed by residents and governmental agencies through lethal measures; shooting, trapping, and poisoning have been used to reduce livestock depredation with varying success (Mitchell et al., 2004). In urban environments, however, lethal control of coyotes has become increasingly

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unacceptable due to public concern for the humane treatment of coyotes, the welfare of non-target wildlife species, and the risk of injury to children and pets (Huot & Bergman, 2007; Jackman & Rutberg, 2015). Non-lethal and effective management approaches to reduce both real and perceived human-coyote conflicts are a central concern for city officials, wildlife managers, and the public (Huot & Bergman, 2007; Lukasik & Alexander, 2011).

Increasing interest in humane management approaches to resolve human-coyote conflict has led to the development of various non-lethal management tools, including deterrents. Deterrents incorporate aversive visual, olfactory, gustatory, tactile, or auditory stimuli that discourage the presence of an animal in a specific area (Smith et al., 2000). Deterrent devices such as flashing strobe lights, fladry, propane exploders, and sirens are commonly employed to prevent coyote depredation in agriculture settings (Mitchell et al., 2004). More invasive measures such as low-powered pellet guns using blunt or rubber bullets have also been used (Baker & Timm, 1998). Many of these devices, however, are unsuitable or illegal to use in urban environments and present safety concerns for humans, pets, and non-target wildlife species (Huot & Bergman, 2007).

The efficacy of deterrents is limited by habituation of coyotes to the presented stimuli over time (Darrow & Shivik, 2009). Habituation can occur when stimuli are not linked to a specific behavior or the stimuli is not noxious enough to prevent an animal from performing an undesired behavior (Shivik et al., 2003). One approach to slow the rate of habituation is behavior-contingent activation whereby a deterrent device is only activated when an animal is performing an undesired behavior (e.g., an animal moving into an area where they are least tolerated, such as residential areas, schoolyards, or playgrounds; Shivik & Martin, 2000). Motion-activated deterrents, in which activation of the device is contingent on the presence of an animal, have been employed for a variety of urban wildlife species including ultrasonic devices for cats (Crawford et al., 2018) and badgers (Ward et al., 2008), laser devices for geese (Werner & Clark, 2006), and light and sounds devices for mule deer and elk (VerCauteren et al., 2005), all with varying success. While research on captive coyotes indicates that behavior-contingent activation may hold promise for deterring coyotes from areas that provide access to food (Darrow & Shivik, 2009; Shivik & Martin, 2000), no studies to date have assessed the use of behavior-contingent activation deterrents for use with free-ranging urban coyotes.

Motion-activated sprinklers are considered a behavior-contingent deterrent and have been suggested for use with urban wildlife, including coyotes (British Columbia Conservation Foundation, n.d.; Colorado Parks and Wildlife, 2011). Despite this device being advertised and available to the public as a humane, relatively low-cost, alternative to lethal control, no published scientific research has assessed the devices' efficacy in deterring urban coyotes. In light of this gap in literature and with the request for research on non-lethal management methods (Breck et al., 2017; Lukasik & Alexander, 2011), the objectives of this article were to determine if a motion-activated sprinkler deterrent could reduce both: (a) the frequency of coyote visits to urban residential yards and (b) the time urban coyotes spend in residential yards.

Methods

Field work was conducted from June 2018 to January 2019 in residential areas of the Metro Vancouver Regional District (MVRD) of British Columbia, Canada. Media releases through online newspaper, television, and radio interviews were conducted to facilitate recruitment of residential study participants. Participants were asked to report property location and estimated weekly number of coyotes; self-reporting was employed to initially identify potential study sites and to screen for participant interest in the study. Potential study sites were required to meet two conditions, the site had to: (a) be located in a residential area of MVRD with a back or front yard large enough for a sprinkler with a 6 m spray distance to be installed, and (b) have regular coyote activity on the property, defined as a minimum of two coyote visits on at least two separate days, for a one-week time period.

From June to November 2018, camera traps (Bushnell Trophy Cam HD Aggressor No Glow, Bushnell Corp., Kansas, USA) were installed in residential yards that met condition (a), and had self-reported regular coyote activity. Installed cameras were used to monitor the actual number of coyote visits to determine if the site met condition (b) and could be included as a study site. To increase detection probability (O'Connor et al., 2017), up to six camera traps were placed along the perimeter of each site to maximize the spatial coverage of the yard and, if possible, to monitor attractants such as gardens, fruit trees, birdfeeders, garbage, and composting areas. Camera traps collected data 24 hours a day and were programmed to take three images, one every second, when the motion sensor was activated.

Deterrent Device Testing

The non-lethal deterrent used in this article was a commercially available infrared motion-activated sprinkler advertised to deter pets and urban wildlife from residential gardens and backyards (Orbit 62120 Garden Enforcer Motion-Activated Sprinkler, Orbit Irrigation Products Inc., Utah, USA). The device uses an infrared motion sensor to detect movement and triggers a spray of water emitted from a water valve. To monitor coyotes' behavioral response to the deterrent, the sprinkler's spray zone was set to overlap with the camera traps' field of view. From October 2018 to January 2019, the deterrent was tested in three consecutive phases at selected study sites. In Phase 1, the camera traps were placed at sites for 30 days without the deterrent present. In Phase 2, the deterrent was installed and cameras were kept in the same position for 30 days. At the completion of Phase 2, the sprinkler was removed and the camera traps were kept in place for 30 days to monitor coyote activity in Phase 3 of the study.

Image and Data Analysis

Images collected during the three phases were reviewed with Timelapse2 Image Analyzer 2.2.1.4, that allowed for visual examination and extraction of date and times for all images (Greenberg, 2018). Individual coyotes were indistinguishable in the images; therefore, the total number of coyote images were used as an index for overall coyote activity. To determine independence of coyote visits, consecutive coyote images with at least 10 minutes elapsed between images constituted a separate visit. This 10-minute threshold was based on analysis of the frequency distribution of the daily time intervals between coyote images for a 46-day period at one study site. As 95% of the total daily coyote images were captured with a time interval less than 10 minutes apart, consecutive coyote images taken more than 10 minutes apart were defined as an independent visit. A similar threshold was used by Breck et al. (2017) and Breck et al. (2019) for coyote camera trap images and videos, respectively.

Daily frequency and duration of coyote visits were calculated manually, with visit duration defined as the time elapsed between the first and last coyote image captured by all cameras at a site. Coyote images from two days in Phase 2 were excluded from analysis as the sprinklers froze due to cold weather conditions. Due to a severe windstorm the duration of Phase 3 was shortened to 19 days as there was significant damage to the residential landscape which did not allow for camera images to be taken using the same positions used in Phases 1 and 2. Additionally, coyote visits with one photo were not included as the duration of the visit could not be calculated. A two-sample *t*-test was used to determine if there was a significant difference in the mean number of coyote visits and mean duration of visits across the phases using Microsoft Excel 16.23.

Results

Media releases resulted in 15 residential participants stating they had regular coyote activity in their yards. From this, three residential sites met initial study conditions (a) and (b) and were included in the study. However, only one study site was used for data analysis due to unforeseen weather conditions (freezing temperatures, a windstorm) that affected the equipment and site accessibility requiring exclusion of two sites.

A total of 491 images of coyotes were collected from the residential site over 79 days of camera trap placement. Coyotes visited the study site across all phases; however, the total frequency of coyote visits were lower in the deterrent phase (Phase 2, $n = 8$), than in the pre-deterrent phase (Phase 1, $n = 36$), and the post-deterrent phase (Phase 3, $n = 11$).

The mean number of daily coyote visits was significantly lower in the deterrent phase than the pre-deterrent phase (Figure 1; $t = 3.17$, $p = .003$). There was no significant difference between the mean number of daily coyote visits in the pre-deterrent phase and the post-deterrent phase ($t = 1.64$, $p = .11$).

In contrast, there was no significant difference between the mean duration of coyote visits in the deterrent phase and pre-deterrent phase (Figure 2; $t = 1.52$, $p = .15$). However, once the

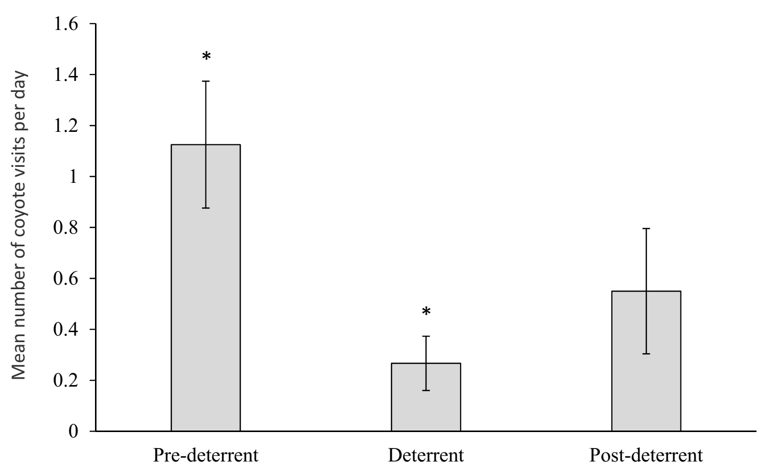

Figure 1. Mean number of coyote visits (± S.E.M.) per day (24-hour period) to a residential yard across all phases. Asterisks indicate statistical differences between phases, * $p \leq .05$.

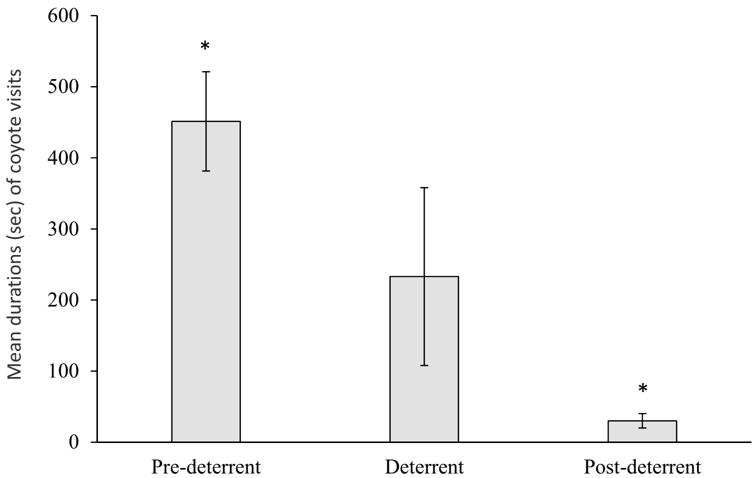

Figure 2. Mean duration (± S.E.M.) of coyote visits (in seconds) to a residential yard across all phases. Asterisks indicate statistical differences between phases, * $p \leq .05$.

deterrent was removed in the post-deterrent phase, the mean duration of coyote visits was significantly lower when compared to the pre-deterrent phase ($t = 5.96$, $p < .001$).

Discussion

This article provided the first assessment of the efficacy of motion-activated sprinklers for deterring urban coyotes from residential areas and encourages further work into the development and testing of humane deterrent devices for urban coyotes. Preliminary evidence suggested that sprinklers temporarily reduce the number of daily coyote visits to a residential yard. These results coincide with previous studies that indicate coyotes were less likely to enter areas protected by sound and light deterrents to access food (Darrow & Shivik, 2009; Shivik & Martin, 2000). Research indicates that captive coyotes exhibit avoidance behaviors toward novel objects (Mettler & Shivik, 2007; Windberg, 1996) and suggests that this behavior may be due to distrust or caution (Harris & Knowlton, 2001). However, it is difficult to determine if coyotes in this study visited the residential yard less frequently in the deterrent phase because they were cautious of the physical sprinkler structure, found the audible clicking noise from the sprinklers water valve or the water spray aversive, or a combination of both. As such, future studies testing a combined tactile and auditory deterrent with three treatments testing the tactile, auditory, and combined stimuli could provide novel insight into coyotes' behavioral responses to deterrents.

We found no difference in the mean duration of coyote visits between the pre-deterrent and deterrent phases. This result contradicts previous studies where the duration coyotes spent in close proximity to food attractants was reduced with the presence of a visual novel object, such as wooden stakes adorned with ropes (Breck et al., 2019) and fladry (Mettler & Shivik, 2007). In the present study, once the deterrent was removed coyotes spent less time visiting the residential site than in the pre-deterrent phase. However, it is unclear if this observed reduction in the mean visit duration was due to learned avoidance of the sprinkler or was a combination of internal and external factors. For example, changes in human or pet activity near the study site, weather, food availability, and the coyote's seasonal life cycle could influence coyote behavior and movement patterns irrespective of the sprinkler.

Limitations of this article highlight areas of research that warrant further exploration. For example, research demonstrates that seasonal life cycles can alter coyote behavior and movements patterns (Harrison, 1992; Holzman et al., 1992). Within the scope of this study we were unable to test the sprinkler deterrent across multiple seasons, thus limiting our inferences to the long-term efficacy of sprinkler deterrents. As previous research indicates that the efficacy of deterrents varies across individual coyotes (Breck et al., 2019; Darrow & Shivik, 2009), future research should consider factors such as coyotes' social status, personality, and territorial range to improve the overall understanding of the efficacy of deterrents for application in varying residential areas and within urban coyote populations (Blackwell et al., 2016).

While this article is limited in scope, results offer preliminary evidence that sprinkler deterrents hold promise for reducing the presence of coyotes in residential areas, thereby encouraging future research into humane deterrents for use with urban coyotes. No individual tool will be effective for reducing conflict between humans and carnivores across human-modified landscapes (Shivik et al., 2003), and it is necessary to develop and scientifically validate a variety of humane deterrents to minimize human-coyote conflicts. As coyotes rely heavily on their visual senses over their auditory or olfactory senses for hunting (Wells & Lehner, 1978), visual deterrents are likely to be effective. As such, potential devices that warrant further investigation with urban coyotes should include visual stimuli such as blinking lights, fladry, and motion-activated light devices.

This article contributed to the growing body of scientific literature on urban coyote management and subsequently can help inform management strategies to improve human-coyote coexistence. Findings from this article supported the suggestions of Lukasik and Alexander (2011) that aversive conditioning may keep coyotes away from areas where they are least tolerated, such as residential areas, playgrounds, or schools. Based on our preliminary findings, we suggest that sprinklers be used in combination with other practices that reduce the risk of human-coyote conflict, including the removal of food and habitat attractants in residential areas (e.g., fallen fruit from trees and areas under porches that are potentialdenning sites) in addition to not leaving pets outside unattended (Timm et al., 2004; White & Gehrt, 2009). Specifically, sprinklers could be placed near food attractants such as gardens, garbage, or compost in residential yards as an attempt to prevent coyotes establishing feeding patterns in residential neighborhoods and reduce the risk of food conditioning. The findings of this article and similar deterrent studies may also be integrated into public education programs to provide homeowners with humane methods to reduce human-coyote conflicts. Collectively, studies examining the efficacy of humane deterrents for urban coyotes can contribute toward improving human-coyote coexistence in shared landscapes between humans and coyotes.

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