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Treat Yourself: Pilot Testing a New Method to Treat Mange in Wild Carnivores

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ABSTRACT: Mange is a skin disease caused by mites that parasitize an animal's skin, often yielding inflamed immune responses and hair loss. At a population level, mange may reduce survival and cause population declines. Many forms of mange can be treated quite effectively when an animal is in hand; however, this is not often feasible for many free-ranging wildlife populations. Some animals, particularly territorial carnivores, will rub or roll to scent mark and transmit information about their presence to other individuals. We posited that rub stations comprised, in part, of anthelmintic medication and foreign scents that induce rubbing could be used to remotely treat mange in the wild. We deployed 39 rub stations containing lure and dye in Santa Monica Mountains National Recreation Area, Southern California, USA, October–November 2022. Carnivores rubbed or rolled at >97% of rub stations, with coyotes (*Canis latrans*), gray foxes (*Urocyon cinereoargenteus*), and bobcats (*Lynx rufus*) being the most abundant species. Time to first rub or roll was generally <1 wk. Several sympatric species (e.g., mule deer, *Odocoileus hemionus*) were detected at rub stations but did not rub. Our pilot test provides strong evidence that treating mange in wild carnivores may be possible using the remote medicinal rub stations we describe. Future efforts to add medicine to rub stations and monitor for a change in mange prevalence are a logical next step.

Key words: Carnivores, disease, mange, roll, rub, treatment.

Mange is a skin disease caused by mites that parasitize an animal's skin, resulting in an inflammatory immune response and behaviors such as scratching at the infection site, causing hair loss and lesions (Escobar et al. 2022). Mange is caused by various mites (e.g., *Sarcoptes scabiei*, *Demodex* spp., *Notoedres* spp.) and some species are rapidly spreading (Escobar et al. 2022). Sarcoptic mange is one of the fastest-spreading wildlife diseases in the world and has led to population declines in many wildlife species (Escobar et al. 2022). Notoedric mange (caused by *Notoedres cati*), which often infects wild cats (e.g., bobcats, *Lynx rufus*), can also reduce survival (Foley et al. 2016) and even population density (Riley et al. 2007). Certain types of mange (e.g., sarcoptic) may even be more prevalent in human-dominated landscapes that facilitate high host densities, mite transmission, and increased risk of spillover from reservoir domestic host species such as dogs (*Canis familiaris*; Escobar et al. 2022) and llamas (*Lama glama*) to novel wild host species. There is also a strong association between exposure to higher levels of anticoagulant rodenticides and death from notoedric mange in bobcats in Southern California, US, (Riley et al. 2007; Serieys et al. 2015). Animals in protected areas also experience mange outbreaks. Gray wolves (*Canis lupus*) in Yellowstone National Park, USA experienced a population decline after an outbreak of sarcoptic mange reduced survival and even led to extirpation of some infected packs (Almberg et al. 2012). Ironically, the presence of mange in this protected National Park is due to humans introducing the mite to control carnivore populations in the nearby region in the early 1900s (Smith and Almberg 2007).

There are many efficacious topical or oral treatments against mange (e.g., avermectins and isoxalines); however, topical medicines require the animal to be in hand (Rowe et al. 2019). Some of the treatments may require multiple doses, depending on the class of drug and severity of mange infestation (Rowe et al. 2019; Wilkinson et al. 2021). It is not often feasible to capture wild animals or hold them in captivity for treatment. Recently, wombat (*Vombatus ursinus*) managers in Tasmania, Australia used a creative approach to treat mange outbreaks in the population by placing flaps over burrows, which dispensed medicine onto an individual's back when it left its burrow (Martin et al. 2019). Although specific to burrow-dependent species, this provides an example of mange treatment in free-living animals without capture. A recent review by Rowe et al. (2019) suggested that future research should strive to create medicine delivery alternatives to darting or capture and handling to treat mange in wild animals.

Some animals, particularly territorial carnivores, will rub or roll to scent mark and transmit information about their presence to other individuals in the population (Macdonald et al. 2010; Vogt et al. 2014). Biologists have exploited such rubbing behavior to obtain hair samples noninvasively from individuals at remote rub stations, extract DNA, and ultimately estimate carnivore population size (e.g., Weaver et al. 2005; Rounsville et al. 2022). The addition of foreign scents and lures to rub stations, particularly those high in sulfides, may elicit a rub or roll response from several species known to develop mange, such as coyotes (*Canis latrans*), Canadian lynx (*Lynx canadensis*), and wolves (*C. lupus*; McDaniel et al. 2000; Ausband et al. 2011). We wanted to know if we could exploit the propensity of carnivores to rub on foreign odors to treat mange in the wild. Specifically, we posited that rub stations comprised, in part, of mange medicine plus foreign scents that induce rubbing could be used for future remote treatment of mange outbreaks in free-ranging wildlife. We conducted a pilot test of this technique by deploying rub stations constructed of a rub device containing liquid and dye as well as foreign odors known to elicit rub responses in carnivores.

In October–November 2022, we deployed 39 rub stations for 2 mo on public lands in and around Santa Monica Mountains National Recreation Area (SMMNRA), California, US, just northwest of the city of Los Angeles. The SMMNRA is a 638-km^2 area of mixed habitats including grasslands, oak (*Quercus* spp.) woodlands, and predominantly shrublands such as chapparal and coastal sage scrub. Land ownership in the area is a mix of public open space and private property. There is extensive urban and suburban development within the park boundary including commercial, industrial, and especially residential areas, and extensive human recreation in and around the park (Ruell et al. 2009).

Nearly half (20/39) of the sites where we deployed rub stations were along game trails at randomized locations previously established by the park for a camera survey; the remaining 19 rub stations were deployed on game trails with signs of high animal use in regions where animals with mange had been reported previously. Rub stations included a natural eye catcher (e.g., large rock, log, or bone), scented lure, and rub station device. We set the eye catcher directly behind the rub station device to attract animals and focus their roll or rub onto our rub station device. We deployed 5.0 mL of sulfide-based lure and 5.0 mL of catnip (not used during the first 2 wk of the study), known to attract bobcats and coyotes, onto the eye catcher directly behind the rub station device. Each rub station device included food dye (10%) and perfume-free dish soap (90%). We used food dye in place of mange medication for this pilot test, to determine whether animals that rubbed or rolled had visible liquid on their fur. Dish soap is miscible with medication (e.g., selamectin; R. Williams pers. comm., University of Idaho) and helps combat desiccation. The mixture of dye and dish soap was placed inside three cells (3.75 cm) of plastic bubble wrap using a 10-mL syringe and 16-gauge needle. The small hole created from the 16-gauge needle allowed the liquid and dye to escape the bubble wrap when an animal depressed it. The bubble wrap was affixed to a small (5.0 cm × 7.5 cm) board, making a rub station device, that was driven into the ground (Fig. 1) and lightly sprinkled with dirt.

We used cameras to assess rub station effectiveness. We deployed one Reconyx PC900 camera (Reconyx, Holmen, Wisconsin, USA) at each rub station and recorded 1) species visitation rates; 2) roll/rub behavior frequency (rub = parts of body contact rub station but not spine; roll = spine as well as other parts of body contact rub station); and 3) mange infection rates. We attempted to summarize any visible mange on animals by recording whether an animal had raw, hairless patches on its rump or legs or whether there were numerous crusts on an animal's face or tail. Cameras were deployed at

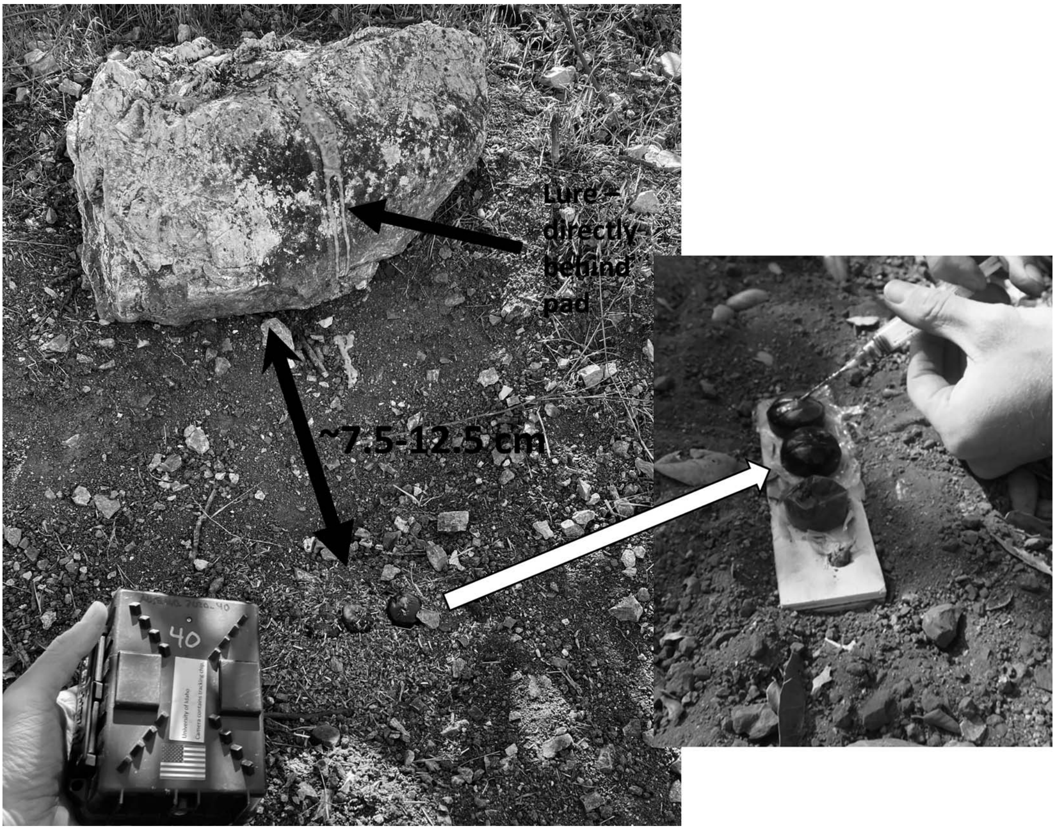

FIGURE 1. Rub station made of wood and plastic bubble wrap containing food dye and liquid dish soap. Inset: Bubble wrap being filled. A trail camera is in the visible hand.

heights <1.0 m, set for high sensitivity, covert infrared flash, and 45-s video recordings after each trigger. Each station was revisited approximately every 2 wk to refresh lure, dye, and soap (which often hardened or evaporated if not rubbed) and download videos.

We recorded more than one rub or roll event at 97.4% (38/39) of rub stations. We observed 210 total rub or roll events (Fig. 2), largely from three species: 124 by coyotes, 63 by gray foxes (*Urocyon cinereoargenteus*), and 23 by bobcats. Several sympatric species (e.g., raccoon, *Procyon lotor*; badger, *Taxidea taxus*; striped skunk, *Mephitis mephitis*) were detected but did not interact with rub stations except for one domestic dog, which rubbed at one station.

Of the three most commonly detected species at rub stations, gray foxes (n=96 detections) rubbed most frequently (63 rubs; 65.6% of the time they were detected), followed by coyotes (323 detections, 124 rubs, 38.5%) and bobcats (87 detections, 23 rubs, 26.4%; Fig. 3). Gray foxes tended to rub largely on their chins and underside of their necks, whereas coyotes typically dropped a foreleg to the ground and

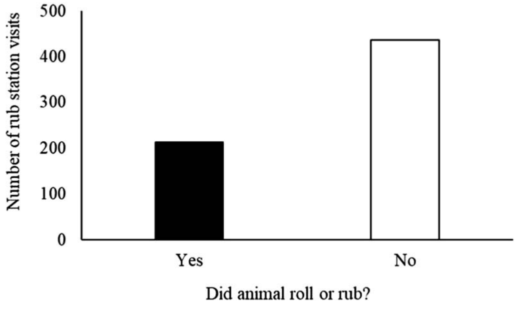

FIGURE 2. Number of rub or roll events from wildlife species detected at rub stations in and around Santa Monica Mountains National Recreation Area, California, USA, October–November 2022.

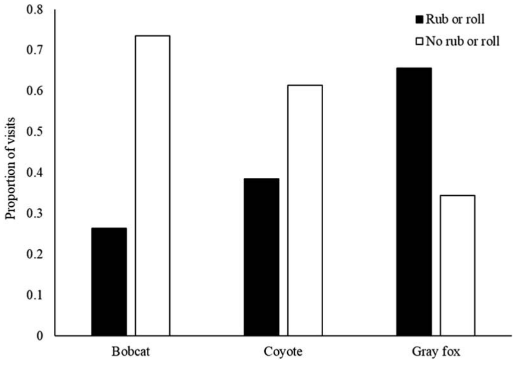

FIGURE 3. Proportion of rub and roll events per visit by bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and gray foxes (*Urocyon cinereoargenteus*) at rub stations in and around Santa Monica Mountains National Recreation Area, California, USA, October–November 2022.

rubbed on their shoulders. Finally, bobcats typically sat on the rub stations for a brief period until eventually rolling over onto their spines and sides repeatedly (Fig. 4a–c). Time to detection and time to first rub or roll were generally less than 1 wk. Of the three most commonly detected species at rub stations, gray foxes rubbed within mean 3.8 d (SD 4.0), followed by coyotes at 6.5 d (SD 4.7) and bobcats at 8.7 d (SD 5.5; Fig. 5). Time between rubs or rolls of the same species was mean 7.6 d (SD 9.5), whereas time between rubs or rolls of one species and a different species was 4.5 d (SD 5.1). These estimates do not include rub stations where a species rubbed or rolled and no species rubbed or rolled thereafter for the duration of deployment. Nineteen animals had observable dye on them after rubbing or rolling at stations. The only species with visible mange was coyotes, with nearly 8% (26/323) of detections showing visible signs of mange-like lesions, though none of these lesions was severe or widespread on the animal.

Our pilot test provided strong evidence that treating mange in wild carnivores may be possible using the medicinal rub stations we describe. Carnivores routinely rubbed or rolled on our rub station devices and numerous animals showed evidence of dye on their bodies. We note that we checked rub stations every 2 wk and generally animals had visited the stations in the interim

FIGURE 4. Examples of (a) bobcat (*Lynx rufus*); (b) coyote (*Canis latrans*); and (c) gray fox (*Urocyon cinereoargenteus*) rubbing and rolling at rub stations in and around Santa Monica Mountains National Recreation Area, California, USA, October–November 2022.

(Fig. 5); thus, most (134/210, 63.8%) animals rubbed at stations where the dye was already gone. In addition to dye being unavailable at some sites after another animal had rubbed, most visits were at night (65.4%) and dye was not as visible in the resulting black and white nighttime videos from our cameras. In the future, the food dye used in our study could be replaced with an appropriate pharmaceutical agent (e.g., selamectin) to treat mange.

Observable signs of mange-like lesions were restricted to coyotes in our study. Some animals may have had mange and gone undetected

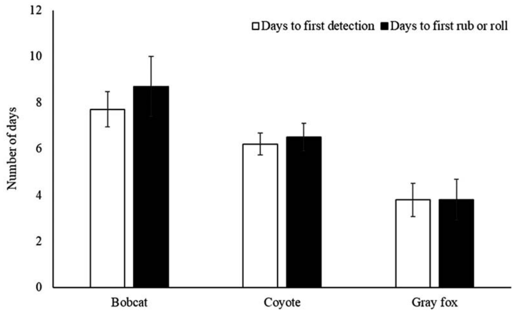

FIGURE 5. Number of days to first detection and first rub or roll event for bobcats (*Lynx rufus*), coyotes (*Canis latrans*), and gray foxes (*Urocyon cinereoargenteus*) at rub stations in and around Santa Monica Mountains National Recreation Area, California, USA, October–November 2022. Error bars represent the standard error of the mean.

because not all types of mange cause hair loss and animals with early-onset mange may not show visible signs of infection. Indeed, some mange outbreaks may involve a large proportion of individuals showing no signs of infection (Escobar et al. 2022). There were verified reports of bobcats with severely progressed mange infections during our study, but they were not in areas where we had rub stations. We currently do not know if animals with severe mange infections would rub or roll at medicinal rub stations.

More frequent rub station checks are recommended and should be done on the basis of the mean time to first rub for the most common species at rub stations. On the basis of results from gray fox activity at rub stations in our study, this would mean checking and refreshing rub stations every 4 d. It may be possible to target felids and not canids by using just catnip at rub stations, because bobcats only rubbed after we deployed catnip. Additionally, the area at a rub station could be treated with a mild acid (e.g., tannic acid from oaks) to kill any potential mites that may be in the soil from an infected animal rubbing. The number of days between rubs or rolls among or within species was approximately 5–8 d. Mange mites are thought to persist without a host for just a short time (as short as 2 d; Arlian et al. 1989), although some mites can survive without a host for up to 3 wk in very high humidity. Treating stations with an environmentally safe disinfectant or acid would reduce the chance of spreading mange to other animals after a visit from an infected individual. Finally, moving rub stations just a few meters after a rub event would help prevent cross-contamination. Moving rub stations would also combat the propensity of some animals not to rub or roll after another has defecated or urinated on a station.

The different rub or roll behaviors exhibited by different species at rub stations may affect how well individual animals take up medicine. For example, gray foxes rubbed chiefly under their lower mandible and the underside of their necks, where hair is shorter than along their sides; thus they may be more likely to get medicine on their skin where it can be taken up more efficiently. By contrast, bobcats rubbed along their backs and sides where hair is typically dense and relatively longer, yet bobcats also rubbed and rolled for long periods of time, sometimes for multiple video recordings (i.e., >90 s). Future efforts could attempt to maximize medicine transfer to individuals on the basis of the target species' behavior at rub stations. Cameras set to record videos are a valuable tool for discerning such behaviors.

We typically could not identify individuals and it is likely that the same individuals visited the same or even several rub stations more than once. Thus, the potential to overdose an individual may exist. The half-life for selamectin, for example, is approximately 12–41 d, and studies show no adverse effects on animals receiving doses every 28 d (Selamectin Safety Data Sheet, Zoetis Inc., Parsippany–Troy Hills, New Jersey, USA). It would be advantageous to carefully study the efficacy of the medicine to be used. Additionally, assessing the efficacy of medicine in different temperatures and designing a sampling protocol with that in mind would be useful. Finally, if animals ingest medicine through observed grooming, practitioners may consider changes to sampling protocols or cessation altogether for a time. One could monitor cameras at rub stations at frequent intervals, and when an animal has rubbed or rolled, decommission the station for a given length of time if overdosing is a suspected problem. Given that animals typically left many hairs at stations, one could collect hairs for DNA analyses to determine which individuals are visiting stations. Such a method would greatly increase costs and the time involved, however. Last, topical medicines to treat mange may degrade because of ultraviolet (UV) exposure. Although immersing them in a miscible solution as we used here would likely help to minimize degradation, rub stations could also be deployed in the shade to help combat UV degradation.

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