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Exposure of Wildlife to Anticoagulant Rodenticides at Santa Monica Mountains National Recreation Area: From Mountain Lions to Rodents

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ABSTRACT: A 15-year study of carnivores in an urban landscape in southern California has revealed a high incidence of exposure of non-target wildlife to anticoagulant rodenticides (ARs). All carnivore species studied, including mountain lions, coyotes, bobcats, and gray foxes, have tested positive for exposure to the toxicants. Anticoagulant residues have been detected in post-mortem liver samples at a rate of 83-93% of individuals tested, for coyotes, bobcats, and mountain lions, the 3 species for which we have extensive sampling. We have also documented mortalities caused directly by exposure to ARs in all 4 species, particularly in the canids. In both felid species, we found a positive correlation between AR exposure and mange disease, specifically notoedric mange. The incidence of fatal mange infection in bobcats has been at epizootic levels since 2002 in our study area, and more recently outbreaks of the disease have been documented in several other populations in California, all apparently (where testing has been done) in association with exposure to ARs. There are no previously reported instances of epizootics of notoedric mange in any wild felid population. Carnivore exposure to these toxicants appears to be largely secondary (or tertiary, as may be the case in mountain lions) through consumption of their natural prey. In our most recent work, we have evaluated AR exposure of carnivore prey species, including rodents and lagomorphs. We have documented exposure in ground squirrels and woodrats, both of which are regularly consumed by gray foxes, coyotes, and bobcats. Overall, we have found widespread exposure of non-target wildlife to these toxicants, with potentially significant consequences for some species.

KEY WORDS: anticoagulants, bobcat, *Canis latrans*, coyote, gray fox, *Lynx rufus*, mountain lion, *Puma concolor*, rodenticides, secondary hazard, small mammals

INTRODUCTION

Small mammal behavior and ecology, particularly that of rodents, can conflict with human interests in urban and agricultural settings, but current control practices are affecting non-target wildlife species as well. The abundant resources in these urban and agricultural areas attract some small mammal species, as well as enable their high proliferation. As a result, these animals can cause major losses of and damages to goods and property, which has lead to widespread efforts to control small mammal populations in these areas. Currently one of the most popular rodent control methods is using anticoagulant rodenticides (ARs), which interrupt the animal's vitamin K recycling process and inhibit clotting factors, eventually allowing fatal hemorrhaging. First-generation anticoagulant rodenticides (FGARs) have been in use since the 1950s and require multiple feedings in order to have a lethal effect on the target species. However, due to the development of resistance of target species to FGARs, second-generation anticoagulants rodenticides (SGARs) were introduced in the 1970s and 1980s (Erickson and Urban 2004). These compounds can have effects from a single feeding, but they also persist longer in the

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environment and in the livers of exposed animals (Erickson and Urban 2004; Giraudoux et al. 2006; Vandenbroucke et al. 2008). This, coupled with the relatively long delay of effect of these compounds (5-10 days from feeding to death) (Erickson and Urban 2004), leaves other wildlife especially vulnerable to secondary poisoning from consumption of the target species. Secondary exposure and toxicosis has been reported from both FGARs and SGARs in many species from raptors to mammals (e.g., Giraudoux et al. 2006, McMillin et al. 2008, Elmeros et al. 2011, Thomas et al. 2011). Animals that exist in or near areas of heavy human use may be particularly vulnerable to possible deleterious effects of exposure to ARs.

Santa Monica Mountains National Recreation Area (SMMNRA) is the largest urban park within the U.S., and it is next to one of the largest urban centers in the U.S., Los Angeles. There are many areas of natural habitat in and around the mountains that have been completely isolated from core areas of open space by roads and urbanization. However, there still exist within the mountains large areas of natural habitat, as well as significant plant and animal resources in both these large core areas and in the smaller fragmented areas. In addition, both the large and

fragmented natural areas provide significant recreational resources for a large number of park visitors every day. These natural landscapes also provide a desirable location for residents, leading to an interwoven network of urbanized and natural landscapes in the interface areas. Furthermore, neighborhood parks and golf courses interdispersed through the residential areas create altered open space which, while often used by wildlife, may not provide all of the same elements of natural space for all species. This type of complex urban wildland interface can present significant human-wildlife conflicts and additional challenges for wildlife.

Carnivores are particularly sensitive to urban habitat fragmentation due to their large food and space requirements (Crooks 2002). Habitat fragments often become too small to support individual animals, so they must link multiple fragments together if they are to persist in these areas, and therefore they must navigate through the urban partitions. Additionally, resources such as the lush lawns, green foliage, and inhabitable structures found in the urban areas attract small mammals and other herbivores to the area, which subsequently may further attract carnivores to the area. These are likely some of the contributing factors leading to the use of urban areas and adjacent open spaces by carnivores, which leave them particularly vulnerable to anthropogenic influences and conflicts with humans. This is likely the case in SMMNRA where large carnivores, including mountain lions (Puma concolor), covotes (Canis latrans), bobcats (Lynx rufus), and gray foxes (Urocvon cinereoargenteus), still persist in some areas, but the highly fragmented landscape has led to carnivores using areas in and directly adjacent to human development.

REVIEW OF PAST SMMNRA CARNIVORE STUDIES

In 1996, the National Park Service began studying carnivores in the SMMNRA region, including coyotes, bobcats, and gray foxes. Initial studies were conducted through radio telemetry, scat analysis, and remote camera traps. Animals were captured with padded footholds early in the study and later caught with neck snares (for coyotes, the Collarum[™], Wildlife Control Supplies, East Granby, CT) and cage traps. For handling, bobcats were anesthetized while covotes and foxes where physically restrained. Animals were marked with unique ear tags and fitted with radio telemetry collars. Morphometric measurements, as well as tissue and blood samples, were taken. Animals were then monitored through ground triangulation supplemented with remote camera captures. Scat was initially collected opportunistically and analyzed for diet consumption for all three species. Beginning in 2001, standard scat lines were designated and scat numbers for covotes and bobcats were used to compare relative densities of each of the carnivores spatially and temporally, in addition to collection for diet analysis. For animals that died during the study, full necropsies were performed and organ samples were collected for further analysis. Livers were sent to the California Animal Health and Food Safety Laboratory at UC Davis for anticoagulant residue analyses. They were analyzed using an HPLC method, previously published by Palazoglu et al. (1998) and modified for tissue analysis (see also Riley et al. 2007).

We found all 3 carnivores present in the study area, including in many of the small habitat fragments, where there was evidence of use at least from bobcats and covotes. In and around SMMNRA among areas with varying levels of urbanization, 114 covotes (1996-2004) and 160 bobcats (1996-2011) have been followed through telemetry. Coyotes and bobcats both had relatively high densities in the urban fragmented areas, and survival rates were relatively high as well (Riley et al. 2003, 2010). Both species frequently utilized natural habitat in areas directly adjacent to urbanization and occasionally utilized urban areas as well. However, both species prefer the natural habitat, and the majority of their telemetry locations fell in these areas (Riley et al. 2010). Gray foxes were also prevalent in the larger core areas of habitat, where we followed 28 foxes with radio telemetry, but seemed to be rare in the smaller more urbanized habitats fragments, where only 2 foxes were captured and followed.

Coyotes, foxes, and bobcats were all found to have similar prey in their diets, although coyotes and foxes also consumed fruits, while bobcats were strictly carnivorous. Rabbits (*Sylvilagus* spp.) were the most frequently consumed item for bobcats and after fruit were also the most frequently consumed item for coyotes. Rabbits were also important in fox diets (Fedriani et al. 2000). Bobcats and coyotes consumed pocket gophers (*Thomomys bottae*), voles (*Microtus californicus*), woodrats (*Neotoma* spp.), and squirrels (*Otospermophilus beecheyi*, *Sciurus niger*) and for bobcats, these were all important prey, second only to rabbits. However, woodrats and squirrels were significantly less frequent in coyote scats than some of the other prey items. When combined, rodents were the most important prey type for foxes (Fedriani et al. 2000).

In the fall 1997, we detected the first coyote mortality due to AR toxicosis. The necropsy showed large amounts of free blood in the body cavities and the liver contained high levels of FGAR residues. Subsequently, 13 additional cases of fatal AR toxicosis were detected in coyotes between 1996 and 2004. All of these cases had high levels of SGARs, and 4 cases had both SGARs and FGARs. AR toxicosis was the second highest source of mortality for coyotes behind vehicle collisions, and constituted 23% of the total mortality observed and 30% of the observed mortality for which there was a known source. Further, 83% (n=24) of all coyotes tested post-mortem were positive for one or more AR compound residues in their liver.

In addition to high exposure of coyotes to ARs, we also observed exposure in the other 2 carnivore species, bobcats and foxes, all likely due to secondary poisoning. Of bobcats tested post-mortem from 1997-2011, 93% (*n*=89) were positive for one or more AR compound residues (largely SGARs) in their liver, and 77% were positive for multiple compounds. Additionally, 1 of the 2 urban foxes followed died directly from AR toxicosis. As generalists, it is feasible that coyotes and foxes could be eating the baits directly. However, due to their strictly carnivorous diets, it is unlikely that bobcats are being exposed through direct consumption of the AR baits. Commonly targeted pest species such as squirrels, woodrats, and pocket gophers

(Morzillo and Schwartz 2011), are regularly consumed by bobcats, coyotes, and foxes in urban areas, and these prey species are likely the source of AR exposure in carnivores. SGARs are only labeled for use on commensal rodents, but comprise a large portion of the ARs detected in the carnivores. Carnivores may consume some commensal rodents (*Rattus* spp., *Mus musculus*) as well, although these rodents were not common in the carnivore diet studies or in small mammal studies carried out in the area (Schutte 2005, Moriarty, unpubl. data). They may also be acquiring SGARs from ingesting non-target small mammals consuming baits placed for commensal rodents, or because of off-label use of these baits by homeowners or others.

Despite the high exposure rates, we observed just 1 bobcat mortality directly attributed to AR toxicosis. Rather, the largest source of mortality for bobcats from 2002 to 2008 was notoedric mange (Notoedres cati), a parasitic skin disease that causes severe puritis (itching), skin lesions, alopecia (hair loss), and cachexia (weight loss and muscle atrophy), eventually leading to death. We detected the first case of mange in a bobcat in late 2001, after which the disease seemed to quickly elevate to epizootic levels by 2003 when it resulted in 9 out 15 mortalities and the annual bobcat survival rate (probability of an animal surviving one year) dropped dramatically to 0.255 from a previous 7-year average of 0.710. In the years following, mange continued to cause widespread mortality in the study area, and in 2005 it was responsible for 100% of the observed mortalities (Riley et al. 2010). This epizooticdriven population decline was further detected through capture success which diminished in 2004-2008 despite similar trapping effort, and was also strikingly apparent in the numbers of scats counted over this time period, which dropped off dramatically in 2003 and continued to remain low through 2008.

There is little information in the literature about mange disease in felids and almost none on mange disease in wild felids. There are also no present reports of mange epizootics in wild felid with severe population effects similar to that seen in the local SMMNRA populations, although recently outbreaks of the disease have been documented in several other bobcat populations in California (Riley et al. 2010; Serieys, unpubl. data; D. Clifford, CA Dept of Fish & Game, Sacramento, pers. commun.; M. Jennings, CA State Univ., San Diego, pers. commun.). Mange in felids may act as an opportunistic disease, affecting individuals that have been compromised in some other way, and there is evidence to suggest that that may be the case here. We have found a strong statistical correlation and possibly synergistic effect in bobcats between AR exposure and mange disease (for data collected prior to 2004 see Riley et al. 2007), although at this point we have not determined a mechanism producing this correlation. However, bobcats exposed to ARs at a liver residue level of 0.05 ppm or greater are 9 times more likely to die with severe notoedric mange disease than to die of other causes (Serieys, unpubl. data). Further, the other state-wide mange outbreaks (where testing has been done) have all shown concurrent exposure to ARs as well (Riley et al. 2010; Serieys, unpubl. data; D. Clifford pers. commun.; M. Jennings, pers. commun.).

Beginning in 2002, the SMMNRA carnivore project was expanded to include mountain lions, the top predator in the region, and subsequently we have seen high AR exposure in lions as well. Lions were captured primarily with footsnares and with cage traps, and were anesthetized for handling. Hounds were used for some recaptures. They were marked with unique ear tags and fitted with GPS and radio telemetry collars. Morphometric measurements and tissue and blood samples were also taken. Animals were then monitored remotely through downloads of GPS locations as well as VHF triangulation, especially for kittens marked with VHF implants (Moriarty et al. 2011). Lions used much larger areas for their home ranges than any of the other carnivores, with ranges up to 100 times larger than those of bobcats. They also used natural areas directly adjacent to urbanization and occasionally made excursions into the urban areas. However, like the other carnivores, they spent most of their time in natural areas.

Mountain lion scat is rarely found and therefore it is not easily used for diet analysis. However, mountain lions often make large kills on which they will feed for multiple days, and therefore we were able to identify areas where their GPS locations become localized for greater than 24 hours, which generally indicates they are feeding on a kill. We were then able to investigate these kill areas at a later date and determine the prey taken. From these kill investigations, we have learned that lions in our area consume 3-4 mule deer (Odocoileus hemionus) per month and occasionally take smaller prev such as covotes, raccoons (*Procyon lotor*), and badgers (*Taxidea taxus*). They may be also consuming even smaller items, such as rabbits and woodrats that we were not detecting through this method. Further, this method may inherently underestimate the amount of all of the smaller prey items lions are taking, which can be consumed in less than 24 hours, including other carnivores such as coyotes. Therefore, despite the low observation of AR targeted species consumption, lions may be acquiring anticoagulants secondarily similarly to the other carnivores. However, in the case of lions, they are also likely acquiring ARs on a tertiary level from ingesting other carnivores such as covotes. Nine out of 10 lions tested post-mortem were positive for SGAR residues in their liver, including a 3-month-old kitten, and 6 of these cases had FGAR residues as well. Further, 2 of these lions died directly from AR toxicosis, both of whom had consumed coyotes shortly before their death (Riley et al. 2007; Uzal et al. 2007).

CURRENT SMMNRA RESEARCH

In response to the mange epizootic in bobcats and its potential link with AR exposure, we initiated additional components of our carnivore research in 2007. This included expanding sample collection and testing at carnivore captures to better assess animal health and detect early mange disease or AR exposure. Expanded sampling included collecting scat, hair, skin scrapings, ear swabs, urine, and additional blood for expanded blood chemistry, AR residue, and clotting time (PT– prothombin time, and PIVKA – proteins involved in vitamin K absence) tests. We also began trapping efforts in more remote areas of SMMNRA to gather health information on individuals less likely to be exposed to urbanization and therefore ARs. Further, we began using GPS-equipped collars on bobcats in order to obtain more frequent and more precise location data on both the urban and more remote animals. Finally, we began a project to look at exposure to ARs in common prey species of bobcats and coyotes. This project included trapping rabbits, woodrats, and squirrels along urban edges and in more remote areas for comparison, as well as collecting liver samples from small mammals found dead from vehicle collisions or other causes.

For our expanded trapping efforts, we trapped and monitored bobcats in the western, least developed end of SMMNRA. A total of 13 bobcats were trapped, GPScollared, and monitored in this area over a 3-year period (2008-2011). Most of the home ranges of these bobcats consisted entirely of natural areas, with only 2 individuals' home ranges encompassing small amounts of agricultural area, and no home ranges encompassing any urbanized areas. We observed 5 mortalities during the study, none of which resulted from AR toxicosis or mange disease. Exposure to ARs in these animals was low, but not absent. In fact, 2 individuals that appeared to have no urbanization or agricultural lands within their home range both had trace levels of AR residues in their livers tested post-mortem. Although these animals were in the most natural areas of the park, the edge of their observed home ranges were still within 1 km of private ranches, so exposed prey may have been present in their home ranges, or these bobcats may have made visits to the ranches that we did not document. It is also possible these bobcats were exposed to ARs through illegal marijuana cultivation, a known issue in SMMNRA. Gabriel et al. (2012) saw high AR exposure in fishers (Martes pennanti) from remote areas in central California, which they hypothesized to result from rodent control activities at marijuana grow sites.

Small mammal sample testing is still in progress; however, preliminary results show potentially high exposure in small mammals available to predators. Small mammals were live trapped, bled, and tested for clotting times and blood AR residues in 10 sites, 2 in natural areas and 8 urban. Clotting time was assessed using the CoagDX machine (Idexx, Westbrock, ME) for prothrombin time (PT). Our detection of AR exposure from blood tests taken during trapping was low. There was no difference in the mean PT between natural and urban sites for any species. However, there were 2 outliers observed in the urban area, 1 woodrat and 1 rabbit, with PTs around 3 times greater than the means for each species. We also had 2 blood samples test positive for AR residues, both from woodrats and both from urban sites. Our detection of ARs was much greater in post-mortem liver samples taken from small mammals found dead, mostly on roads. Of livers tested, 20% (*n*=51) were positive for AR compounds including 20% of squirrels (n=21) and 4 out of 5 woodrats, one of which was found dead 500 m away from the urban edge. No evidence of AR exposure has been detected in rabbits.

DISCUSSION

Our research has shown that there is widespread exposure of multiple carnivore species to the common ARs used for rodent control. Over 85% of mountain lions, coyotes, and bobcats tested have been exposed to ARs, as well as 1 of 2 foxes. These species that prey on the species targeted for control are not just acquiring incidental exposure to ARs, but rather they are being clinically affected by their exposure. Further, ARs are not only affecting individual covotes, mountain lions, and foxes, as well as potentially indirectly affecting individual bobcats, but they may also be having population level effects on bobcats and potentially foxes. Mange disease is affecting bobcats at a rate in which it appears to be regulating the local population level (Riley et al. 2007). Our research has shown that mange disease is correlated with exposure to ARs, and indicates there may be a potential synergistic relationship. It is unclear why fox densities are so low in the urban areas, but we do know that they are sensitive to and exposed to ARs in these areas. ARs may potentially be a contributing factor.

High levels of exposure in free-roaming small mammals in conjunction with widespread carnivore exposure indicates that current rodent control activities (whether legal or off-label use) are putting all predatory species at risk. All of the small mammals from which samples were collected, both live captures and those found dead, were collected outside of residential homes and vards, and therefore represent animals that would have been available for predation. Furthermore, these exposed animals may actually be more likely to be predated, as they may become sickly and slower before their demise. The habitat loss and fragmentation in urbanized areas may already represent the upper tolerance limits for disturbance of some species. Additional challenges, such as exposure to toxicants, may increase the pressures on some populations and make it harder for them to survive in this landscape. This may be the case with gray foxes in SMMNRA. We know they are sensitive to AR toxicosis, and that they are in low densities in the urban areas. We also know that fox densities seem to have an inverse relationship with coyote densities (Fedriani et al. 2000), which are relatively higher in the more urban parts of SMMNRA (Fedriani et al. 2001). Coyotes alone may keep fox densities low, but AR toxicants may also contribute or at least further reduce their ability to maintain stable populations in fragmented areas.

As urbanization increases both nationally and globally, insuring human coexistence with wildlife will become imperative for some species if they are to persist. Rodents can cause large and costly amounts of damage to goods and property, and the need to control them in some areas is evident, but current methods appear to be costly to natural ecosystems. Comprehensive solutions may not be immediately available, but more targeted and controlled use of ARs, both temporally and spatially, might allow equally effective control with less secondary poisoning. Additionally, long-term use of SGARs may prove to have similar consequences as long-term use of FGARs, i.e. rodents may develop higher tolerances to the SGAR compounds. This may eventually render them ineffective for control. Ultimately, research such as ours will hopefully help pest control managers find more effective alternatives to ARs with fewer unintended consequences for non-target wildlife.

LITERATURE CITED

- CROOKS, K. R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conserv. Biol. 16:488-502.
- ELMEROS, M., T. K. CHRISTENSEN, and P. LASSEN. 2011. Concentrations of anticoagulant rodenticides in stoats *Mustela erminea* and weasels *Mustela nivalis* from Denmark. Science of the Total Environment 409:2373-2378.
- ERICKSON, W., and D. URBAN. 2004. Potential risks of nine rodenticides to birds and non-target mammals: A comparative approach. Report P.2004.27 A, Office of Pesticide Programs, U.S. Environmental Protection Agency Washington D.C. 230 pp.
- FEDRIANI, J. M., T. K. FULLER, and R. M. SAUVAJOT. 2001. Does availability of anthropogenic food enhance densities of omnivores mammals? An example with coyotes in southern California. Ecography 24:325-331.
- FEDRIANI, J. M., T. K. FULLER, R. M. SAUVAJOT, and E. C. YORK. 2000. Competition and intra guild predation among three sympatric carnivores. Oecologia 125:258-270.
- GABRIEL, M. W., L. W. WOODS, R. POPPENGA, R. A. SWEITZER, C. THOMPSON, S. M. MATTHEWS, J. M. HIGLEY, S. M. KELLER, K. PURCELL, R. H. BARRETT, G. M. WENGERT, B. N. SACKS, and D. L. CLIFFORD. 2012. Anticoagulant rodenticides on our public and community lands: Spatial distribution of exposure and poisoning of a rare forest carnivore. PLoS ONE 7(7).
- GIRAUDOUX, P., C. TREMOLLIÈRES, B. BARBIER, R. DEFAUT, D. RIEFFEL, N. BERNARD, E. LUCOT, and P. BERNY. 2006. Persistence of bromadiolone anticoagulant rodenticide in *Arvicola terrestris* populations after field control. Environ. Res. 102:291-298.
- MCMILLIN, S. C., R. C. HOSEA, B. F. FINLAYSON, B. L. CYPHER, and A. MEKEBRI. 2008. Anticoagulant rodenticide exposure in an urban population of the San Joaquin kit fox. Proc. Vertebr. Pest Conf. 23:163-165.
- MORIARTY, J. G., L. WHITED, J. A. SIKICH, and S. P. D. RILEY. 2011. Use of intraperitoneal radiotransmitters to study mountain lion (*Puma concolor*) kittens. Wildl. Soc. Bull. 36:161-166.

- MORZILLO, A. T., and M. D. SCHWARTZ. 2011. Landscape characteristics affect animal control by urban residents. Ecosphere 2:1-16.
- PALAZOGLU, M. G., E. R. TOR, D. M. HOLSTEGE, and F. D. GALEY. 1998. Multiresidue analysis of nine anticoagulant rodenticides in serum. J. Ag. Food Chem. 46:4260-4266.
- RILEY, S. P. D., E. E. BOYDSTON, K. R. CROOKS, and L. M. LYREN.
 2010. Bobcats (*Lynx rufus*). Pp. 121-138 *in*: S. D. Gehrt, S. P. D. Riley, and B. L. Cypher (Eds.), Urban Carnivores. The Johns Hopkins University Press, Baltimore, MD.
- RILEY, S. P. D., C. BROMLEY, R. H. POPPENGA, F. A. UZAL, L. WHITED, and R. M. SAUVAJOT. 2007. Anticoagulant exposure and notoedric mange in bobcats and mountain lions in urban Southern California. J. Wildl. Manage. 71:1874-1884.
- RILEY, S. P. D., R. M. SAUVAJOT, T. K. FULLER, E. C. YORK, D. A. KAMRADT, C. BROMLEY, and R. K. WAYNE. 2003. Effects of urbanization and habitat fragmentation on bobcats and coyotes in Southern California. Conserv. Biol. 17:566-576.
- SCHUTTE, R. N. 2005. The abundance and distribution of small mammals relative to habitat fragmentation in the Santa Monica Mountains National Recreation Area. MS thesis, California State University-Los Angeles, Los Angeles, CA.
- THOMAS, P. J., P. MINEAU, R. F. SHORE, L. CHAMPOUX, P. A. MARTIN, L. K. WILSON, G. FITZGERALD, and J. E. ELLIOTT. 2011. Second generation anticoagulant rodenticides in predatory birds: Probabilistic characterisation of toxic liver concentrations and implications for predatory bird populations in Canada. Environ. Intl. 37:914-920.
- UZAL, F. A., R. S. HOUSTON, S. P. D. RILEY, R. POPPENGA, J. ODANI, and W. BOYCE. 2007. Notoedric mange in two freeranging mountain lions (*Puma concolor*). J. Wildl. Dis. 43:274-278.
- VANDENBROUCKE, V., A. BOUSQUET-MELOU, P. DE BACKER, and S. CROUBELS. 2008. Pharmacokinetics of eight anticoagulant rodenticides in mice after single oral administration. J. Vet. Pharmacol. Therapeut. 31:437-445.