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Ecological Factors Driving Uptake of Anticoagulant Rodenticides in Predators

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ABSTRACT: In recent years, anticoagulant rodenticides have emerged as an important factor reducing the survival of many birds of prey and some predatory mammals (Berny and Gaillet 2008, Jacquot et al. 2013, Poessel et al. 2015, Serieys et al. 2015, Murray 2017). Understanding the ecological factors driving the exposure of predators is a key component in assessing the risk posed by anticoagulant rodenticides. We have reviewed the literature to better understand and synthesize the ecological factors driving AR exposure in predators, focusing on landscape and environmental management, traits of the exposed predators and the most common exposure pathways. On a global scale, the large output of ARs, in particular the more toxic and persistent second generation ARs into urban and agricultural settings and the relatively large footprint of these landscapes, has led to widespread AR exposure of many species, ranging from insects to large carnivores (Dowding et al. 2010, Sánchez-Barbudo et al. 2012, Serieys et al. 2015, Alomar et al. 2018). The methods of applying ARs vary widely, and can range from fastening bait stations to the outside or inside perimeter of buildings, to placing AR bait in underground burrows in fields, to mass application of ARs in agricultural fields and orchards (Corrigan 2001, Rattner et al. 2014). The scale of AR field application varies from a couple of hectares to mass application of ARs on a regional scale (3,000 - 10,000 km^2) to control rodent outbreaks (Jacquot et al. 2013, Baldwin et al. 2014). General inferences can be made with regards to the traits of the most affected predators. We determined that at-risk predators tend to be nocturnal opportunistic predators for which rodents are a key dietary component, seasonally or year-round (Birks 1998, Jacquot et al. 2013, Hindmarch and Elliott 2015, Serieys et al. 2015). They also tend to be non-migratory and occupy habitats within, or in close proximity to landscapes that are heavily influenced by human activities such as intensive agriculture or urban areas (Birks 1998, Way et al. 2006, Elmeros et al. 2011, Christensen et al. 2012, Cypher et al. 2014, Nogeire et al. 2015, Poessel et al. 2015, Serieys et al. 2015, Hindmarch et al. 2017). Predators that consume rats in urban environments are disproportionately affected by ARs (Lambert et al. 1981, Hindmarch and Elliott 2014, 2015). As our understanding of how ARs are transferred up the food-chain is still limited, there is a need to further comprehend the extent to which non-target prey are being exposed to ARs in different landscapes, as we are frequently documenting AR residues in predators that do not typically prey on rodents (Dowding et al. 2010, Ruiz-Suárez et al. 2014, López-Perea et al. 2015). We recommend a focus on urban landscapes, where to date no exposure data has been collected on non-target prey. We also have a very limited understanding of non-target prey exposure in the urban-wildland/agricultural interface where opportunistic predators are known to hunt both habitat types interchangeably. Finally, we need to decipher whether the mounting evidence of exposure in predators translates into any sub-lethal and population levels effects. For a more in-depth review of this topic, we refer to the chapter "Ecological Factors Driving Uptake of Anticoagulant Rodenticides in Wildlife" (Hindmarch and Elliott 2018) in the book *Anticoagulant Rodenticides and Wildlife* (van den Brink et al. 2018).

KEY WORDS: anticoagulant rodenticides, foraging behaviour, landscape management, non-target hazard, predators, raptors, urban

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LITERATURE CITED

Alomar, H., A. Chabert, M. Coeurdassier, D. Vey, and P. Berny. 2018. Accumulation of anticoagulant rodenticides (chlorophacinone, bromadiolone and brodifacoum) in a non-target invertebrate, the slug, *Deroceras reticulatum*. Science of the Total Environment 610-611:576-582.

Baldwin, R. A., N. Quinn, D. H. Davis, and R. M. Engeman. 2014. Effectiveness of rodenticides for managing invasive roof rats and native deer mice in orchards. Environmental Science and Pollution Research 21:5795-5802.

Berny, P., and J-R. Gaillet. 2008. Acute poisoning of red kites (*Milvus milvus*) in France: data from the Sagir network. Journal of Wildlife Diseases 44:417-426.

Birks, J. D. S. 1998. Secondary rodenticide poisoning risk arising from winter farmyard use by the European polecat *Mustela putorius*. Biological Conservation 85:233-240.

Christensen, T. K., P. Lassen, and M. Elmeros. 2012. High exposure rates of anticoagulant rodenticides in predatory bird species in intensively managed landscapes in Denmark. Archives of Environmental Contamination and Toxicology 63:437-444.

Corrigan, R. 2001. Rodent control: a practical guide for pest management professionals. GIE Inc., Cleveland, OH.

Cypher, B. L., S. C. McMillin, T. L. Westall, C. Van Horn Job, R. C. Hosea, and B. J. Finlayson. 2014. Rodenticide exposure among endangered kit foxes relative to habitat use in an urban landscape. Cities and the Environment 7:1-18.

Dowding, C. V., R. F. Shore, A. Worgan, P. J. Baker, and S. Harris. 2010. Accumulation of anticoagulant rodenticides in a non-target insectivore, the European hedgehog (*Erinaceus europaeus*). Environmental Pollution 158:161-166.

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.

Hindmarch, S., and J. E. Elliott. 2014. Comparing the diet of great horned owls (*Bubo virginianus*) in rural and urban areas of southwestern British Columbia. Canadian Field-Naturalist 128:393-399.

Hindmarch, S., and J. E. Elliott. 2015. When owls go to town: the diet of urban barred owls. Journal of Raptor Research 49:66-74.

Hindmarch, S., and J. E. Elliott. 2018. Ecological factors driving uptake of rodenticides in predators. Pages 229-258 *in* N. W. van den Brink, J. E. Elliott, R. F. Shore, and B. A. Rattner, editors. Anticoagulant rodenticides and wildlife. Springer International Publishing, Cham, Switzerland.

Hindmarch, S., J. E. Elliott, S. Mccann, and P. Levesque. 2017. Habitat use by barn owls across a rural to urban gradient and an assessment of stressors including, habitat loss, rodenticide exposure and road mortality. Landscape and Urban Planning 164:132-143.

Jacquot, M., M. Coeurdassier, G. Couval, R. Renaude, D. Pleydell, D. Truchetet, F. Raoul, and P. Giraudoux. 2013. Using long-term monitoring of red fox populations to assess changes in rodent control practices. Journal of Applied Ecology 50:1406-1414.

Lambert, A., T. Murrelet, and N. Spring. 1981. Presence and food preferences of the great horned owl in the urban parks of Seattle. The Murrelet 62:2-5.

López-Perea, J. J., P. R. Camarero, R. A. Molina-López, L. Parpal, E. Obón, J. Solá, and R. Mateo. 2015. Interspecific and geographical differences in anticoagulant rodenticide residues of predatory wildlife from the Mediterranean region of Spain. Science of the Total Environment 511:259-267.

Murray, M. 2017. Anticoagulant rodenticide exposure and toxicosis in four species of birds of prey in Massachusetts, USA, 2012-2016, in relation to use of rodenticides by pest management professionals. Ecotoxicology 26(8):1041-1050.

Nogeire, T. M., J. J. Lawler, N. H. Schumaker, B. L. Cypher, and S. E. Phillips. 2015. Land use as a driver of patterns of rodenticide exposure in modeled kit fox populations. PLoS ONE 10(8):e0133351.

Poessel, S. A., S. W. Breck, K. A. Fox, and E. M. Gese. 2015. Anticoagulant rodenticide exposure and toxicosis in coyotes (*Canis latrans*) in the Denver metropolitan area. Journal of Wildlife Diseases 51:265-268.

Rattner, B. A., R. S. Lazarus, J. E. Elliott, R. F. Shore, and N. van Den Brink. 2014. Adverse outcome pathway and risks of anticoagulant rodenticides to predatory wildlife. Environmental Science and Technology 48:8433-8445.

Ruiz-Suárez, N., L. A. Henríquez-Hernández, P. F. Valerón, L. D. Boada, M. Zumbado, M. Camacho, M. Almeida-González, and O. P. Luzardo. 2014. Assessment of anticoagulant rodenticide exposure in six raptor species from the Canary Islands (Spain). Science of the Total Environment 485-486:371-376.

Sánchez-Barbudo, I. S., P. R. Camarero, and R. Mateo. 2012. Primary and secondary poisoning by anticoagulant rodenticides of non-target animals in Spain. Science of the Total Environment 420:280-288.

Serieys, L. E. K., T. C. Armenta, J. G. Moriarty, E. E. Boydston, L. M. Lyren, R. H. Poppenga, K. R. Crooks, R. K. Wayne, and S. P. D. Riley. 2015. Anticoagulant rodenticides in urban bobcats: exposure, risk factors and potential effects based on a 16-year study. Ecotoxicology 24:844-862.

van den Brink, N. W., J. E. Elliott, R. F. Shore, and B. A. Rattner. 2018. Anticoagulant rodenticides and wildlife: introduction. Pages 1-9 *in* N. W. van den Brink, J. E. Elliott, R. F. Shore, and B. A. Rattner, editors. Springer International Publishing, Cham, Switzerland.

Way, J. G., S. M. Cifuni, D. L. Eatough, and E. G. Strauss. 2006. Rat poison kills a pack of eastern coyotes, *Canis latrans*, in an urban area. Canadian Field-Naturalist 120:478-480.