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Monitoring Anticoagulant Rodenticides in Birds of Prey in the Wildlife Rehabilitation Setting

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ABSTRACT: Monitoring anticoagulant rodenticide (AR) exposures in birds of prey presented to a wildlife clinic or rehabilitation setting has several advantages and disadvantages. Advantages include the ability to document signs of toxicosis in live birds. Additionally, in birds that die due to AR toxicosis, post-mortem lesions in the non-frozen, non-autolyzed cadaver will illustrate patterns of AR-induced hemorrhage. In birds that die or are euthanized due to other causes, liver samples can be collected and analyzed for AR residues. Disadvantages include an inability to ascertain the dose of AR ingested. In birds with exposure to multiple ARs, the timing of ingestion is also unknown. The route of exposure and pathway through the food chain likewise are unknown. Importantly, determining the true incidence of toxicosis and mortality among the sampled birds is not possible because birds that are found and transported for care may not be reflective of mortalities in the overall population. Despite the limitations of this method of sampling, much useful information can be gathered, particularly in studies that are continued over time. Two such monitoring studies conducted in Massachusetts, USA over a ten-year period, showing widespread exposure among sampled birds, will be discussed. In addition, other information that is needed to enhance the data obtained by cadaver sampling will be highlighted, particularly as these data gaps relate to evaluation of mitigation efforts.

KEY WORDS: anticoagulant rodenticides, birds of prey, pesticide use reports, mitigation, wildlife rehabilitation

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INTRODUCTION

Anticoagulant rodenticides (ARs), specifically second-generation ARs (SGARs) are a well-recognized threat to predatory and scavenging wildlife due to their ability to bioaccumulate through the food chain (US EPA 2008, Rattner et al. 2014). To fully understand the impacts of ARs on wildlife, investigation of this problem through multiple routes of study are needed. The wildlife rehabilitation setting offers the opportunity to collect a range of data, including liver residue analysis, as well as ante-mortem and post-mortem observations.

METHODS

Liver Residue Analysis

Monitoring for ARs in four species of birds of prey non-continuously from 2006-2016 has been conducted at the Tufts Wildlife Clinic (TWC) at the Cummings School of Veterinary Medicine at Tufts University in North Grafton, MA. These data have been previously published (Murray 2011, 2017). The four species evaluated in both studies are red-tailed hawks (RTHA, *Buteo jamaicensis*), barred owls (BDOW, *Strix varia*), eastern screech-owls (EASO, *Megascops asio*), and great horned owls (GHOW, *Bubo virginianus*).

From 2006-2010, liver samples from a total of 161 birds that died or required humane euthanasia due to the severity of the injuries were analyzed for AR residues (Murray 2011). Eighty-six percent of these birds were positive for SGAR residues, but no first-generation AR (FGARs) residues were detected. Ninety-eight percent of positive birds had residues of the SGAR brodifacoum only. Two birds had residues of brodifacoum plus the SGAR difethialone.

From 2012-2016, liver samples from a total of 94 birds were analyzed (Murray 2017). Ninety-six percent of these birds were positive for SGAR residues. Two birds contained FGAR residues; however, these birds were additionally positive for SGAR residues, and brodifacoum was present in 99% of the positive birds. However, in contrast to the prior study, 66% contained residues of multiple SGARs. Moreover, a statistically significant increase in birds exposed to multiple SGARs was found over the time period of this study (33% of birds in 2012-2013 vs 79% of birds in 2014-2016). This increase in multiple exposures was driven by continued high exposure to brodifacoum with increased detections primarily of the SGARs bromadiolone and difethialone, and, to a lesser extent, difenacoum.

In both studies, birds were recovered from predominantly suburban and urban landscapes, reflecting residential and commercial uses of ARs, rather than agricultural use (Murray 2011, 2017).

Pesticide Use Reports

US EPA risk mitigation measures aim to minimize use of SGARs by nonprofessionals through point-of-sale and packaging restrictions (US EPA 2008). This mitigation relies on the employment of integrated pest management (IPM) techniques by pest management professionals (PMPs) to decrease risk of SGAR exposure to wildlife. Despite this mitigation, exposure to nontarget species is continuing to occur. Thus, it is important to evaluate the type of use that is resulting in exposure to nontarget species. As a step toward evaluating this pathway, pesticide use reports (PURs) filed yearly with the Massachusetts Department of Agricultural Resources have been reviewed (Murray 2017). In summary, 100 PURs per year for the years 2008, 2009, and 2013-15 were reviewed. These revealed that the chemical rodenticides reported to be used most frequently by PMPs in structural use were

the SGARs bromadiolone, difethialone, and brodifacoum (Murray 2017). The year 2015 saw the highest reported use with over 50% of PMPs reporting use of all three SGARs. The data collected for this study did not allow accurate accounting of total amounts of SGARs used. These data also do not allow for a correlation to be made between PMP use and SGAR exposure in the sampled birds of prey. However, the presence of these three rodenticides in the majority of the birds during roughly the same period (2012-2016) suggests the need for evaluating PMP use of SGARs as a source of exposure in wildlife (Murray 2017).

Ante-Mortem and Post-Mortem Findings in Birds with AR Toxicosis

In the wildlife rehabilitation setting, when a bird is admitted showing signs of AR toxicosis, the individual who recovered the bird can often provide observations that reflect the effects of ARs on these birds in their natural environments. Birds may have been noticed perched in the same spot for several days, encountered on the ground seeming unable to fly away, or even witnessed falling to the ground from a tree (M. Murray, pers. obs.). Ante-mortem signs of AR toxicosis in birds of prey have been detailed previously (Murray 2011, 2017, 2018). In summary, birds admitted to TWC alive that are diagnosed with AR toxicosis commonly show decreased awareness of and responsiveness to their environment and severe weakness, both of which are secondary to blood loss resulting from impairment of coagulation caused by ARs. While generalized or focal hemorrhage can be observed from any location on the bird, common findings include extensive subcutaneous and intramuscular hemorrhage and continuous bleeding from a minor laceration. Basic diagnostics that support AR toxicosis include measurement of a packed cell volume (PCV), which is the percentage of the blood that is comprised of red blood cells and is a parameter that decreases with significant blood loss. In birds with AR toxicosis, the PCV is greatly reduced (often less than 15%, with normal for a bird of prey being 30-40%; M. Murray, pers. obs.).

On post-mortem examination, common additional findings include hemorrhage within the body cavity, hemorrhage into, or originating from, internal organs (lungs, gastrointestinal tract, reproductive tract), hemorrhage within the sternum, and pallor of internal organs (Murray 2011, 2017, 2018). In the wildlife rehabilitation setting, hemorrhage caused by AR toxicosis can be well-documented as post-mortem examinations can be conducted on cadavers that have not been subjected to freezing and thawing and have not undergone decomposition. These processes can introduce confusion regarding interpretation of the appearance of tissues and the presence of bruising or hemorrhage (Murray 2018).

Documentation of these of ante-mortem and/or post-mortem signs is necessary to support a diagnosis of AR toxicosis as the cause of death. Given widespread exposure to ARs among birds of prey (Stone et al. 2003, Berny and Gaillet 2008, Albert et al. 2010, Murray 2011, Stansley et al. 2014, Murray 2017) and uncertainty surrounding the association between AR liver concentrations and toxicosis (Murray 2011, Rattner et al. 2014, López-Perea and Mateo 2018), the finding of AR liver residues alone does not necessarily implicate AR toxicosis as the primary cause of death (Murray 2018).

DISCUSSION

Gaps in Knowledge

While monitoring studies in the wildlife rehabilitation setting such as those conducted at TWC can document the presence of liver AR residues in these birds, and therefore show exposure to ARs, there are many questions surrounding the source of exposure and the conditions that result in signs of toxicosis. Firstly, while exposure to ARs among birds of prey has been shown to be widespread (Stone et al. 2003, Berny and Gaillet 2008, Albert et al. 2010, Murray 2011, Stansley et al. 2014, Murray 2017), there is little knowledge about the route through the food chain ARs take to reach these secondary consumers. Residues of ARs have been documented in both target rodents and nontarget mammals, as well as in songbirds and invertebrates (Elliott et al 2014, Alomar et al. 2018, Shore and Coeurdassier 2018). Wildlife rehabilitation-based studies are not able to determine the prey through which secondary exposure occurs due to the delay between ingestion and the manifestation of signs of toxicosis.

Secondly, the amount of ARs ingested in the prey is not known. Thirdly, the timing and sequence of ingestion, particularly in birds exposed to multiple ARs, is not known. This timing may be relevant to the risk of delayed clotting developing, as it has been shown in rats in the laboratory setting that exposure to brodifacoum increases sensitivity to subsequent dosing with warfarin (Mosterd and Thijssen 1991).

Lastly, and importantly, wildlife rehabilitation studies are unable to accurately reflect the mortality rate due to AR toxicosis in the overall population of these species. The population of birds represented in these studies that are found and transported to a rehabilitation center for care is unknown and confounded by their locale. Those birds that are transported to TWC with signs of AR toxicosis are generally found in urban areas or among residential or commercial areas of suburban towns more likely inhabited by humans (M. Murray, pers. obs.). In these locations, affected birds are more likely to be found than those that may succumb in less visible and human populated areas. Therefore, wildlife rehabilitation-based studies are likely to under-represent mortalities from ARs (Murray 2017).

Conclusions

Despite SGARs having been recognized as a threat to wildlife and mitigation measures having been implemented (Eisemann et al. 2018), they remain in widespread use with corresponding wildlife impacts. Continued efforts to 1) monitor the effects of all ARs on wildlife, 2) lessen these impacts throught mitigation, 3) develop alternative rodent control approaches and toxicants, and 4) promote awareness of the risk of ARs to wildlife among the general public and PMPs are still needed (Elliott et al. 2016, Fourel et al. 2017, Memmott et al. 2017, Buckle and Prescott 2018).

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