PROJECT REPORT

Project Title: Acute Toxicity, Histopathology, and Coagulopathy in American Kestrels(Falco sparverius Following Administration of the Rodenticide Diphacinone

Research Agency: U.S. Geological Survey

Principal Investigator: Barnett A. Rattner

Background:

Monitoring avian species during large-scale rodent eradica- tion operations revealed that several second-generation roden- ticides can result in nontarget mortality and even population- level effects through direct ingestion of bait or consumption of poisoned rodents. Such rodent eradication operations use formulations and application rates that are atypical of more routine use of second-generation rodenticides. Nonetheless, the global mag- nitude of nontarget poisoning of wildlife both in pest eradica- tion programs and in the more routine use of rodenticides is unknown, and most events probably go unnoticed or are not reported.

A risk assessment conducted by the U.S. Environmental Protection Agency (U.S. EPA) in 2002 identified several rodenticides that pose significant risk to birds and nontarget mammals, in part because of their toxicity and prolonged retention in liver [8]. Restrictions on the sale, distribution, and packaging of brodifacoum, difethialone, bromadiolone, and difenacoum were subsequently instituted by the U.S. EPA in 2008 (http://www.epa.gov/pesticides/reregistration/ rodenticides/finalriskdecision.htm). This action will likely be offset by expanded use of acute toxicants and other antico- agulant rodenticides, including diphacinone (http://www.regu- lations.gov/#!documentDetail;D 1/4 EPA-HQ-OPP-2006–0955–0003). The hazard of diphacinone to nontarget organisms is inadequately characterized, although significant exposure and mortality suspected to be related to diphacinone have been reported for raptors (snowy owl, Nyctea scandiaca; red-tailed hawk, Buteo jamaicensis; and Cooper's hawk, Accipiter cooperii). Here, we report overt signs of intoxication, histopathological responses, blood clotting time, residues, and lethality following diphacinone administration to American kestrels (Falco sparverius), a well-studied toxicological model species for raptors. These data, in combination with similar measurements in Northern bobwhite (Colinus virgin- ianus), will assist in the development of a pharmacodynamic model and a more complete risk assessment of diphacinone for birds.

Results:

The acute oral toxicity of the anticoagulant rodenticide diphacinone was found to be

over 20 times greater in American kestrels (Falco sparverius; median lethal dose 96.8 mg/kg body weight) compared with Northern bobwhite (Colinus virginianus) and mallards (Anas platyrhynchos). Modest evidence of internal bleeding was observed at necropsy, although histological examination of heart, liver, kidney, lung, intestine, and skeletal muscle revealed hemorrhage over a wide range of doses (35.1–675 mg/kg). Residue analysis suggests that the half-life of diphacinone in the liver of kestrels that survived was relatively short, with the majority of the dose cleared within 7 d of exposure. Several precise and sensitive clotting assays (prothrombin time, Russell's viper venom time, thrombin clotting time) were adapted for use in this species, and oral administration of diphacinone at 50 mg/kg increased prothrombin time and Russell's viper venom time at 48 and 96 h postdose compared with controls. Prolongation of in vitro clotting time reflects impaired coagulation complex activity, and generally corresponded with the onset of overt signs of toxicity and lethality. In view of the toxicity and risk evaluation data derived from American kestrels, the involvement of diphacinone in some raptor mortality events, and the paucity of threshold effects data following short-term dietary exposure for birds of prey, additional feeding trials with captive raptors are warranted to characterize more fully the risk of secondary poisoning.