DOI: 10.7589/2015-12-321

Journal of Wildlife Diseases, 53(1), 2017, pp. 165–169

Mortality of Western Burrowing Owls (*Athene cunicularia hypugaea*) Associated with Brodifacoum Exposure

Anne Justice-Allen[1,3] **and Kerrie Anne Loyd**[2] [1]Arizona Game and Fish Department, 5000 W Carefree Highway, Phoenix, Arizona 85086, USA; [2]Arizona State University Colleges at Lake Havasu City, 100 University Way, Lake Havasu City, Arizona 86403, USA; [3]Corresponding author (email: ajustice-allen@azgfd.gov)

ABSTRACT: Western Burrowing Owls (*Athene cunicularia hypugaea*) frequently occupy periurban areas, where they may be exposed to pest control agents. This short communication describes necropsy findings and detected brodifacoum rodenticide levels for four Western Burrowing Owls in Lake Havasu City, Arizona, US, 2013–15. Levels detected ranged from 0.077 mg/kg to 0.497 mg/kg. Brodifacoum, one of several second-generation anticoagulant rodenticides recently removed from the general consumer market, is still available for use by licensed pesticide applicators. Despite recent regulatory actions, second-generation anticoagulant pesticides continue to threaten predatory species in periurban areas.

Key words: Brodifacoum, Burrowing Owls, second-generation anticoagulant rodenticide, secondary poisoning.

Anticoagulant rodenticides are the most commonly used class of rodenticide in the world (Eason et al. 2002). Brodifacoum is a second-generation anticoagulant rodenticide (SGAR) that has been favored for the control of commensal rodents. In Arizona, US, these include, among other species, rock squirrels (*Spermophilus variegatus*), brown rats (*Rattus norvegicus*), roof rats (*Rattus rattus*), and woodrats (*Neotoma* spp.). Soon after development, researchers determined that SGARs represented a risk for secondary poisoning of wildlife (Mendenhall and Pank 1980; Merson et al. 1984) and are increasingly associated with secondary poisoning of raptors and small predators (Stone et al. 1999; Eason et al. 2002). In 2008, the US Environmental Protection Agency (USEPA) completed a safety review of rodenticides, and requirements for packaging, distribution, and application of certain SGARs were changed (USEPA 2016). In March 2015, distribution of general consumer products containing brodifacoum and nine other SGARs halted, as required by an agreement between the manufacturer and the USEPA; however, some products remain available for use by licensed pesticide applicators under certain conditions (USEPA 2016).

The Western Burrowing Owl (*Athene cunicularia hypugaea*) is a small owl found throughout the western US and southwestern Canada, which uses rodent burrows for cover and nesting. It preys on small birds, rodents, and arthropods. The species is protected by the Migratory Bird Treaty Act, has been identified as a National Bird of Conservation Concern and a local conservation concern by the US Fish and Wildlife Service (Klute et al. 2003), and is included in the Arizona Game and Fish Department's (AGFD) Species of Greatest Conservation Need (AGFD 2012). Herein, we describe the necropsy findings for three specimens, and toxicology results of four owls from Lake Havasu City, Arizona.

Owl A was submitted to AGFD from Lake Havasu City in February 2013. The clinical behavior was described as abnormal with spastic eye movements. The preliminary gross necropsy diagnosis was head trauma or viral infection. Later, archived tissues were submitted for histologic and toxicologic testing.

In August 2013, Arizona State University Colleges at Lake Havasu City began studying urban Western Burrowing Owl nest success in Lake Havasu City. During the monitoring effort from August 2013 to July 2015, 22 adult Burrowing Owl carcasses, representing approximately 25% of the local adult population (approximately 88), were discovered (Table 1 and Fig. 1). All were found at burrow entrances or within 10 m. There were no signs of predation. While most carcasses were

TABLE 1. Western Burrowing Owl (*Athene cunicularia hypugaea*) mortalities in Lake Havasu City, Arizona, USA, 2013–15. Case letters and corresponding brodifacoum levels correspond to the four mortalities investigated in this report.

Date found	Number found	Age	Carcass[a]	Location[b]	Case	Brodifacoum
7 February 2013	1[c]	Adult	F	U	A	0.077 mg/kg
15 August 2013	2	Adult	S, S	B	—	—
11 February 2014	2	Adult	S, F	B, NB	B	0.367 mg/kg
26 February 2014	1	Adult	R	B	—	—
4 March 2014	1	Adult	R	B	—	—
11 March 2014	1	Adult	R	B	—	—
18 March 2014	1	Adult	R	AB	—	—
20 March 2014	1	Adult	S	B	—	—
24 April 2014	1	Adult	R	B	—	—
7 May 2014	2	Adult	F, R[d]	B	C	0.282 mg/kg
15 May 2014	1	Adult	F[e]	B	D	0.497 mg/kg
29 May 2014	1	Adult	R	B	—	—
24 September 2014	1	Adult	S	U	—	—
26 March 2015	1	Adult	U[f]	U	—	—
2 May 2015	1	Adult	R	B	—	—
8 May 2015	1	Adult	R	B	—	—
3 June 2015	1	Adult	R	NB	—	—
3 June 2015	1	Adult	R	NB	—	—
12 June 2015	1	Juvenile	R[g]	B	—	—
12 June 2015	1	Juvenile	R[g]	B	—	—

[a] F = fresh, estimated time of death ≤32 h; S = skeletal; R = recent, ≤72 h, some tissue remaining though desiccated; U = unknown, not recorded.

[b] U = unknown but in vicinity of burrow; B = burrow entrance; NB = near burrow, 3–10 m; AB = adjacent to burrow (<3 m).

[c] Submitted to Arizona Game and Fish Department by wildlife rehabilitator.

[d] Multiple nestlings also lost and one trapped and taken to wildlife rehabilitation facility.

[e] Remote camera on burrow, male observed bringing *Rattus*, and five of six nestlings also died shortly thereafter.

[f] Carcass collected by public.

[g] Additional juveniles present.

degraded, three (owls B, C, and D) were of sufficient quality for necropsy and toxicologic testing. Three additional mortalities did not fit this pattern and are not included in this report.

The nutritional body condition of all four owls (A–D) was considered good despite nearly empty intestinal tracts. Owls A and C had evidence of hemorrhage at the base of the skull and around the nares, mouth, and over the left cerebral cortex, respectively. Hemorrhage was not detected in owl B, but the tissues were pale suggesting significant blood loss or anemia. The carcass of owl D was autolyzed. Liver samples from the four owls and tissues from owls A–C were submitted to Washington Animal Disease Diagnostic Laboratory for toxicologic and histologic testing, respectively.

Except for confirmation of hemorrhage in owl C, no significant histologic lesions were found in the tissues (cerebellum, lung, heart, liver, spleen, ventriculus, pancreas, small intestine, kidney, and adrenal gland) of owls B or C. Mild, acute bronchiolar inflammation was identified in owl A. Additionally, the cerebellar and meningeal blood vessels of this owl were congested, and the fourth ventricle was filled with blood. Brodifacoum was detected in all four owls (A = 0.077 mg/kg, B = 0.367 mg/kg, C = 0.282 mg/kg, and D = 0.497 mg/kg).

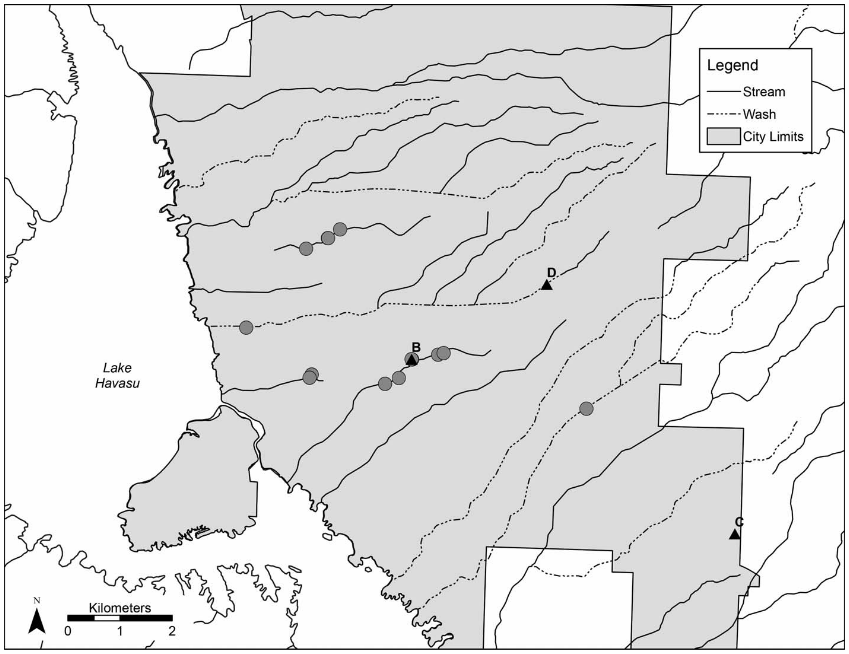

FIGURE 1. Western Burrowing Owl (*Athene cunicularia hypugaea*) mortality locations in Lake Havasu City, Arizona, USA, 2013–15. The collection site for three of the specimens is indicated by the corresponding letter; specimen A was submitted by a wildlife rehabilitator, and the exact location was not identified.

Exposure of raptors to SGARs has become a serious worldwide issue with researchers identifying residues in more than 60% of tested samples (Stone et al. 1999; Langford et al. 2013; Ruiz-Suárez et al. 2014). Mortality is attributed to secondary poisoning only when the exposure is accompanied by hemorrhage, absent evidence of trauma (Murray 2011). However, postmortem autolysis can obscure hemorrhaging, and the presence of anticoagulant rodenticides can cause fatalities from minor traumas (Stone et al. 1999; Rattner et al. 2014). Mortality of Burrowing Owls as a result of SGAR exposure has not been previously reported.

The necropsy findings and brodifacoum levels detected in three of four Burrowing Owls presented herein are consistent with a previous report of secondary rodenticide poisoning (0.012 to 0.269 mg/kg; Murray 2011). Although the condition of the carcass precluded identification of hemorrhage in owl D, exposure may have had a negative effect (Ruiz-Suárez et al. 2014). Brodifacoum has been one of the SGARs more frequently found in carcasses (Stone et al. 1999; Murray 2011). Murray (2011) found brodifacoum in 98% of the SGAR-positive birds, including 87% of Eastern Screech-owls (*Megascops asio*) that were examined. Tissue levels of brodifacoum in birds dying as a result of exposure vary widely within and across species, with lethal effects occurring from 0.11 mg/kg to 2.30 mg/kg in Weka (*Gallirallus australis;* Eason et al. 2002), 0.046 mg/kg to 0.269 mg/kg in Red-tailed Hawks (*Buteo jamaicensis;* Murray 2011), 0.064 mg/kg to 1.613 mg/kg in Great-horned Owls (*Bubo virginianus*, $n=5$, AGFD unpubl. data), 0.035 to 0.314 mg/kg in Golden Eagles (*Aquila chrysaetos*, $n=3$, AGFD unpubl. data). There is concern that current methods of risk assessment have not adequately identified the potential impact of SGAR toxicity to nontarget species (Rattner et al. 2014).

In 2013, the USEPA filed a Notice of Intent to Cancel brodifacoum and three additional SGARs (bromadiolone, difenacoum, and difethialone), and the manufacturer agreed to voluntarily stop distributing consumer products by March of 2015, but there were no requirements for return or destruction of stocks (USEPA 2016). New restrictions placed on products containing these SGARs included placement by licensed applicators, distribution within 30.5 m (100 ft) of buildings or agricultural structures, and use of a tamper-proof bait station whenever children, pets, or nontarget wildlife might have access and for any application outdoors and aboveground (USEPA 2016). However, Bartos et al. (2012) found that some California pest control operators distributed bait incorrectly by placing it >18.25 m (60 ft) from buildings.

Because the carcasses of the other 19 Burrowing Owls were not suitable for testing, we cannot attribute their deaths to secondary rodenticide poisoning. However, given the timing and location in relation to the confirmed cases, direct observation by using a remote camera (Bushnell Trophy Cam, Overland Park, Kansas, USA) and the absence of signs of predation or injury, we suspect that at least some of these birds were exposed to SGAR and died as a result of exposure. Although a disease such as West Nile virus may have caused some of the deaths, the incidence of human West Nile virus in the region is low with only one confirmed and one probable case in the region from January 2013 to December 2015 (Arizona Department of Health Services 2016).

We identified the anticoagulant rodenticide brodifacoum as the cause of death in three Burrowing Owls, and it was suspected for a fourth. Burrowing Owls in Arizona are using urban and suburban areas, where they are particularly vulnerable to the threat of secondary poisoning through consumption of poisoned target and nontarget species. Despite recent regulatory actions, these products continue to be detected in nontarget species. Gervais et al. (2003) recommended a buffer zone of 500–600 m around Burrowing Owl sites to prevent secondary toxicity, but their hunting radius may extend 1,200 m from the burrow. Minimizing the use of brodifacoum during the late summer when juveniles are dispersing is also advised (Gervais et al. 2003). The impact of the mortality on the local population has not yet been determined. Population monitoring will continue through at least the 2016 nesting season, allowing the identification of trends in mortality.

The Wildlife Restoration Act, project W-78-R, granted to the Arizona Game and Fish Department provided funding for this research. Thanks to Joseph J. Osinski for numerous volunteer hours working with the Lake Havasu City Burrowing Owls 2014–15. Thanks to Sue Boe for the map of the Burrowing Owl locations.

LITERATURE CITED

Arizona Department of Health Services. 2016. *West Nile virus*. http://www.azdhs.gov/preparedness/epidemiology-disease-control/mosquito-borne/index.php#west-nile-virus-home. Accessed May 2016.

AGFD (Arizona Game and Fish Department). 2012. *Arizona's State wildlife action plan: 2012–2022*. Arizona Game and Fish Department, Phoenix, Arizona. https://www.azgfd.com/PortalImages/files/wildlife/2012-2022_Arizona_State_Wildlife_Action_Plan.pdf. Accessed August 2016.

Bartos M, Dao S, Douk D, Falzone S, Gumerlock E, Hoekstra S, Kelly-Reif K, Mori D, Tang C, Vasquez C, et al. 2012. Use of anticoagulant rodenticides in single-family neighborhoods along an urban-wildland interface in California. *Cities Environ* 4:12. http://digitalcommons.lmu.edu/cate/. Accessed August 2016.

Eason CT, Murphy EC, Wright GR, Spurr EB. 2002. Assessment of risks of brodifacoum to non-target birds and mammals in New Zealand. *Ecotoxicology* 11:35–48.

Gervais JA, Rosenberg DK, Anthony RG. 2003. Space use and pesticide exposure risk of male Burrowing Owls in an agricultural landscape. *J Wildl Manag* 67:155–164.

Klute DS, Ayers LW, Green MT, Howe WH, Jones SL, Shaffer JA, Sheffield SR, Zimmerman TS. 2003. *Status assessment and conservation plan for the Western Burrowing Owl in the United States*. US Department of Interior, Fish and Wildlife Service, Biological Technical Publication FWS/BTP-R6001-2003, Washington, DC. https://www.fws.gov/mountain-prairie/migbirds/species/birds/wbo/Western%20Burrowing%20Owlrev73003a.pdf. Accessed August 2016.

Langford KH, Reid M, Thomas KV. 2013. The occurrence of second generation anticoagulant rodenticides in non-target raptor species in Norway. *Sci Total Environ* 450–451:205–208.

Mendenhall VM, Pank LF. 1980. Secondary poisoning of owls by anticoagulant rodenticides. *Wildl Soc Bull* 8: 311–315.

Merson MH, Byers RE, Kaukeinen DE. 1984. Residues of the rodenticide brodifacoum in voles and raptors after orchard treatment. *J Wildl Manag* 19:212–216.

Murray M. 2011. Anticoagulant rodenticide exposure and toxicosis in four species of birds of prey presented to a wildlife clinic in Massachusetts, 2006–2010. *J Zoo Wildl Med* 42:88–97.

Rattner BA, Lazarus RS, Elliott JE, Shore RF, van den Brink N. 2014. Adverse outcome pathway and risks of anticoagulant rodenticides to predatory wildlife. *Environ Sci Technol* 48:8433–8445.

Ruiz-Suárez N, Henríquez-Hernández LA, Valerón PF, Boada LD, Zumbado M, Camacho M, Almeida-González M, Luzardo OP. 2014. Assessment of anticoagulant rodenticide exposure in six raptor species from the Canary Islands (Spain). *Sci Total Environ* 485–486:371–376.

Stone WB, Okoniewski JC, Stedelin JR. 1999. Poisoning of wildlife with anticoagulant rodenticides in New York. *J Wildl Dis* 35:187–193.

USEPA (US Environmental Protection Agency). 2016. *Regulating rodenticides*. http://www2.epa.gov/rodenticide. Accessed April 2016.

Submitted for publication 1 December 2015.
Accepted 16 July 2016.