Northern spotted owl | Dave Roelofs, BLM

PESTICIDE EXPOSURES & MORTALITIES IN NON-TARGET WILDLIFE

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

2022 Annual Report
Wildlife Hea lth Laboratory
31 July 2023

2022 SUMMARY OF PESTICIDE EXPOSURES & MORTALITIES IN NON-TARGET WILDLIFE

By Jaime Rudd, Krysta Rogers, & Nicholas Shirky

With contributions from Deana Clifford and Brandon Munk

PREPARED BY THE WILDLIFE HEALTH LABORAOTRY OF THE CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

State of California
Natural Resources Agency
INTRODUCTION

It is the mission of the California Department of Fish and Wildlife (CDFW) to manage California's diverse fish, wildlife, and plant resources, and the habitats upon which they depend, for their ecological values and for their use and enjoyment by the public. As such, a memorandum of understanding was developed between the California Department of Pesticide Regulation (CDPR), the County Agriculture Commissioners (CAC), and the CDFW. The purpose of the memorandum is to ensure that pesticides registered in the state of California are used in a manner that protects non-target fish and wildlife resources, while recognizing the need for responsible pest control.

In partial fulfillment of the MOU, this 2022 annual report summarizes documented pesticide exposure and toxicosis in California's fish and wildlife for the respective authorities of CDPR, CAC, and CDFW. These data represent a minimum number of reports for tested animals that died within the reported calendar year and are subject to change as new information becomes available.

DATA COLLECTION & ANALYSIS

The Wildlife Health Laboratory (WHL, formerly the Wildlife Investigations Laboratory) was established in 1941 and is mandated by Fish and Game Code Section 1008 to investigate all diseases and problems relating to wildlife. The WHL has accomplished this goal through collaboration with the public and various organizations to record, collect, and submit wildlife mortalities of interest to the WHL for examination and further diagnostics as needed. The WHL continues communication with interested parties as new information is discovered to aid further cooperation in the goal of maintaining healthy wildlife populations throughout the state.

Programmatically the WHL is divided into three units which address health issues: 1) avian, 2) large game, 3) small and non-game species. The avian unit oversees nearly 600 avian species including non-game (e.g., songbirds, raptors, shorebirds, waders, and seabirds) and game species (e.g., doves, pigeons, quail, turkey, and waterfowl). The large game unit primarily oversees black bear, bighorn sheep, deer, elk, pronghorn, and wild pig with shared responsibility of small game such as tree squirrels, rabbits, and hares. In addition to sharing health surveillance responsibilities with the large game unit, the non-game unit also oversees native non-game mammals, fur bearers, reptiles, and amphibians. This includes a consortium of species such as California tiger salamander, Western Pond turtles, pika, riparian brush rabbits, skunks, raccoons, foxes, bobcats, mountain lions, and gray wolves.

Wildlife Submissions

Wildlife remains are submitted to the WHL in various ways, primarily by the public – either direct submissions of deceased wildlife to the WHL, submission of living or deceased wildlife to wildlife rehabilitation centers ("rehab"), notification of mortalities to CDFW staff and law enforcement, or other government agency reports (e.g., animal control, sheriff, state and federal Department of Agriculture, U.S. Fish and Wildlife Service, the Park Service, etc.). The WHL also collaborates with universities, non-governmental organizations (NGO), and other agencies on statewide population monitoring projects and provides diagnostic support by conducting postmortem examinations. The WHL contracts with the California Animal Health and Food Safety (CAHFS) Laboratory for further disease and toxicology testing.

Postmortem Examination

Postmortem examinations (necropsies) are performed on wildlife remains at the WHL or the CAHFS Laboratory. If remains cannot be examined within 48-hours of collection, they are stored in a -20°C freezer until an examination can be performed. Prior to necropsy, frozen carcasses are thawed for a few days at 4°C or room temperature until they are ready for necropsy. Sex, age class, body condition and, when

possible, the cause of death is determined. In addition to necropsy, mortality investigations often include microscopic evaluation of tissues (histology) and ancillary disease and toxicology testing. Tissue samples are collected and placed in 10% formalin for histological evaluation and a complimentary set of tissues are archived in -20C° freezers until submitted to the CAHFS Laboratory for analysis.

Carcasses in advanced stages of decomposition and autolysis are necropsied but formalin tissues may not be collected or submitted since autolysis can obscure or destroy microscopic lesions. In these cases, necropsies are performed, and tissue samples are collected for toxicology testing to rule out pesticide exposure but not necessarily toxicosis.

Anticoagulant Rodenticides. Anticoagulant rodenticides are grouped into two categories: "first generation anticoagulant rodenticides" which include warfarin (war), coumachlor (cou), diphacinone (diph), and chlorophacinone (chl) and the more toxic "second generation anticoagulant rodenticides" which include brodifacoum (brd), bromadiolone (brm), difenacoum (dfn), and difethialone (dif).

Liver samples are submitted to the CAHFS Laboratory for testing.

Non-Anticoagulant Rodenticides & Other Pesticides. A number of acutely toxic compounds such as bromethalin, strychnine, zinc phosphide, cholecalciferol, organophosphates, and carbamates are also used to manage rodent and insect pests. Like anticoagulant rodenticides, these compounds, or their metabolites, have been documented in non-target wildlife as a form of mortality or exposure.

Appropriate tissue samples (e.g., gastrointestinal contents, adipose, brain, spinal cord, kidney, liver) for requested tests are also submitted to the CAHFS Laboratory for testing.

Exposure & Toxicosis

Pesticides, including anticoagulant rodenticides, are not always acutely fatal and there is a high degree of variability among species and individuals in their vulnerability. In the absence of a universal threshold residue value that could indicate anticoagulant rodenticide "toxicosis," we must also rely on antemortem and/or postmortem evidence of coagulopathy unrelated to another identifiable cause of hemorrhage (e.g., trauma, disease, infection).

Individuals are considered to have anticoagulant rodenticide "exposure" if their livers had detectable levels of one or more anticoagulant rodenticide residues (regardless of concentration, reported in parts per billion or ppb) and lack antemortem and/or postmortem evidence of coagulopathy.

For non-anticoagulant rodenticides, diagnosing toxicosis requires the detection of the compound in the appropriate tissue sample or gastrointestinal contents, and antemortem and/or postmortem evidence in the absence of another identifiable cause (e.g., disease, infection, trauma).

In some cases, rodenticide residues are detected in the tissue sample, but postmortem evidence could not confirm or exclude toxicosis due to advanced decomposition which precludes a definitive diagnosis. Therefore, these diagnoses are reported as "suspected" or "undetermined" toxicosis.

It is important to note that exposure in the absence of toxicosis should not be ignored[1]. The uncertainties about the magnitude and drivers of chronic exposure and/or sub-lethal levels of rodenticide exposure demonstrate the need for continued monitoring. Exposure to anticoagulant rodenticides may predispose wildlife to excessive hemorrhage following an otherwise non-lethal traumatic injury or increase sensitivity to additional exposure(s)[1].

AVIAN SUMMARY

According to CDFW records at the time of this report, the remains of 1,211 birds were submitted to the WHL for necropsy, and/or disease or toxicology testing in calendar year 2022. Note, the number of birds submitted to WHL in 2022 was roughly twice the average number of birds submitted in previous years. The primary reason for increased submissions during 2022 was the unprecedented outbreak of Eurasian highly pathogenic avian influenza H5N1 that affected a diversity of wild birds and poultry in California, elsewhere in the United States, and globally. The ability to conduct surveillance testing for other diseases and exposure to toxins was impacted by the demand for disease testing for highly pathogenic avian influenza H5N1. Further, highly pathogenic avian influenza viruses are designated as a United States Department of Food and Agriculture select agent and a reportable foreign animal disease. All tissues are required to be immediately disposed of following a confirmed detection to reduce the risk of disease spread, and thus no further testing could be performed.

Waterfowl and waterbirds (n = 563) accounted for the largest percentage of birds submitted, followed by raptors (n = 438). Birds were submitted for various reasons by wildlife rehabilitators, members of the public, non-profit organizations, universities, CDFW staff and law enforcement, and other agencies (Table 1). Wildlife rehabilitators made up the majority of submissions, followed by agencies and specifically, CDFW. However, it should be noted that the majority of these reports originated with a member of the public.

Table 1. Total number of wild bird remains submitted to the Wildlife Health Laboratory for necropsy in 2022 based on the primary submitter's affiliation. Many submissions that are non-public originated as a public report.

Submitter Affiliation	No. Birds Submitted
CDFW	198
NGO/Non-Profit	41
Other Government Agency / Military	71
Private Consultant / Energy	37
Public	38
Rehab / Zoo / Sanctuary	823
University Affiliate	3
Total	**1,211**

Anticoagulant Rodenticide Exposure & Toxicosis

Of necropsied birds, 34 were tested for anticoagulant rodenticide exposure. Tested birds represent 95% (55/58) of California counties (Table 2). All age classes and sexes were represented in submitted carcasses.

Raptors were the largest group to have anticoagulant rodenticide exposure to one or more analyte(s) and/or toxicosis (Table 3). Of the 88.2% of tested birds with detectable levels of anticoagulant rodenticides (30/34), 56.7% (17/30) were cases of anticoagulant rodenticide toxicosis.

More than half of the exposed raptors had two or more second generation anticoagulant rodenticides detected in the liver (Figure 1). Brodifacoum, bromadiolone, difethialone, and diphacinone were the

most common analytes detected in liver samples (Figure 2). None of the birds sampled had detectable levels of exposure to warfarin, difenacoum, or coumachlor.

Other Pesticides

Other pesticide-related investigations involved five separate incidents of mortality including 1) a mourning dove in Sacramento County, 2) rock pigeons in Fresno County, 3) rock pigeons in San Mateo County, 4) a great horned owl in San Luis Obispo County, and 5) a red-tailed hawk in Sonoma County. Avitrol was detected in a rock pigeon submitted from Fresno and San Mateo counties where multiple pigeons were reported with seizures before death. Avitrol was also detected in a single mourning dove reported with seizures before death and submitted from Sacramento County. Strychnine was detected in a great horned owl from San Luis Obispo County and a red-tailed hawk from Sonoma County. The great horned owl had the remains of a songbird in its digestive tract and the red-tailed hawk had the remains of a mourning dove in its digestive tract. The ingested birds were the presumed source of secondary exposure for these raptors as their remains were admixed with strychnine bait in the raptors digestive tract.

American kestrel | Naser Mojtahed, USFWS

Table 2. Exposure prevalence and number of confirmed toxicosis cases of anticoagulant rodenticides in 34 tested wild birds submitted to the Wildlife Health Laboratory in 2022 by county. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

County	No. Tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis
Contra Costa	1	1	100.0	1
Kern	1	1	100.0	1
Los Angeles	5	5	100.0	4
Marin	3	2	66.7	2
Mendocino	2	1	50.0	0
Napa	1	1	100.0	0
Sacramento	4	4	100.0	0
San Bernardino	2	2	100.0	1
San Diego	2	2	100.0	1
San Joaquin	1	1	100.0	0
San Luis Obispo	2	2	100.0	0
San Mateo	1	1	100.0	1
Santa Clara	3	3	100.0	2
Santa Cruz	1	1	100.0	1
Sonoma	2	1	50.0	1
Ventura	3	2	66.7	2
Total	**34**	**30**	**88.2**	**17**

Table 3. Exposure prevalence and number of confirmed toxicosis cases of anticoagulant rodenticides in 34 wild birds submitted to the Wildlife Health Laboratory in 2022 by species (common name). After a postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

Bird Species	No. Tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis
American kestrel	1	0	0.0	0
Barn owl	5	5	100.0	2
Golden eagle	2	2	100.0	0
Great horned owl	16	14	87.5	12
Red-shouldered hawk	4	4	100.0	2
Red-tailed hawk	2	2	100.0	1
Swainson's hawk	1	1	100.0	0
Turkey vulture	3	2	66.7	0
Total	**34**	**30**	**88.2**	**17**

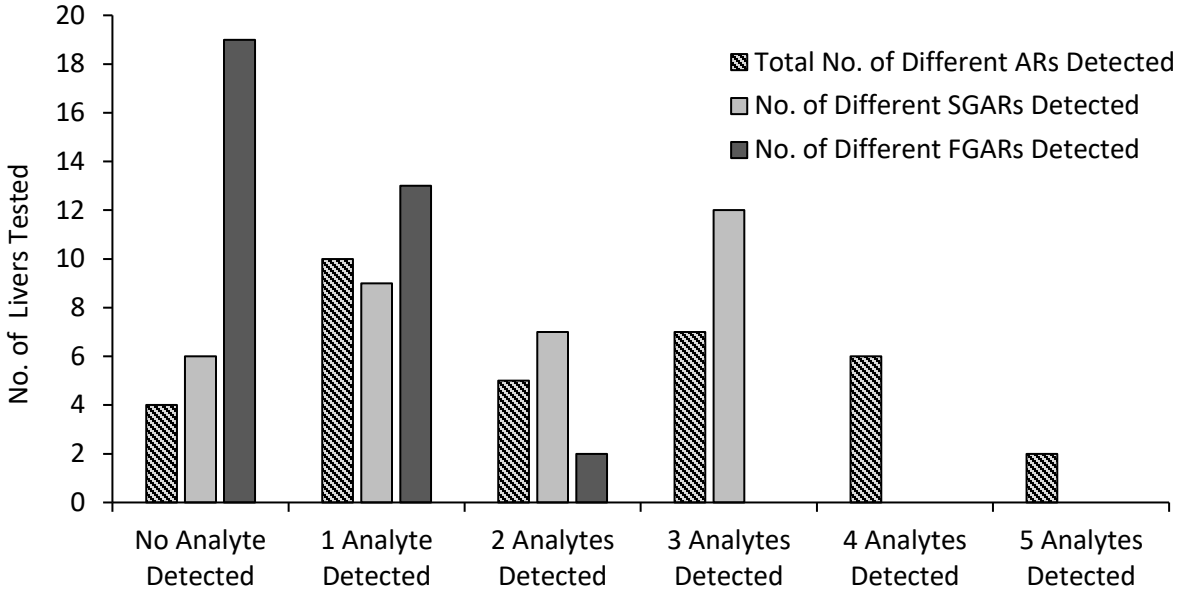

Figure 1. Number of anticoagulant rodenticide residues detected in the livers of 30 wild birds submitted to the Wildlife Health Laboratory for postmortem examination in 2022. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

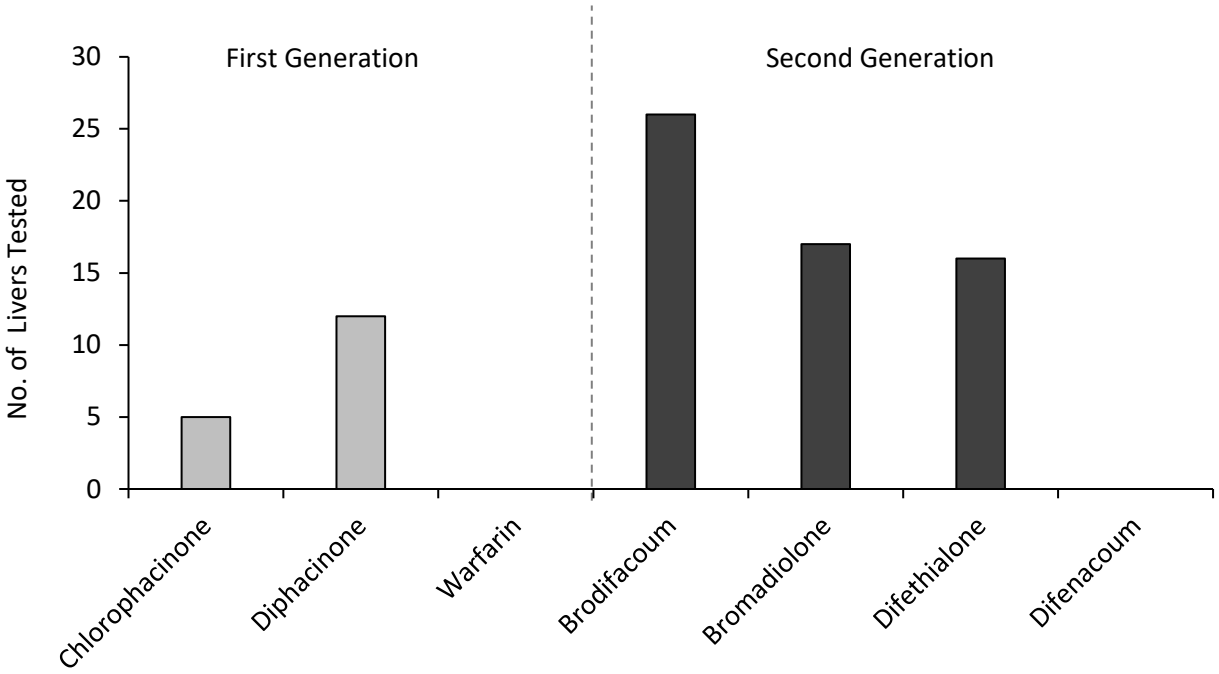

Figure 2. Anticoagulant rodenticide residues detected in the livers of 30 of the 34 tested wild birds submitted to the Wildlife Health Laboratory in 2022. Anticoagulant rodenticides were not detected in 4 of the tested bird livers. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

LARGE GAME SUMMARY

The remains and/or tissues of 68 large game mammals were submitted to the WHL for necropsy and/or toxicology testing in the year 2022.

Approximately 81% (55/68) of the large game carcasses were submitted by the CDFW and other agencies (Table 4). However, it should be noted that public reports represent the original source for most CDFW submissions.

Table 4. Total number of wild large game mammal tissues or remains submitted to the Wildlife Health Laboratory in 2022 based on the primary submitter's affiliation. Many submissions that are non-public originated as a public report.

Submitter Affiliation	No. Large Game Mammals Submitted
CDFW	55
Other Government Agency / Military	1
Private Consultant / Energy	1
Public	3
Rehab/Zoo/Sanctuary	8
Total	68

Anticoagulant rodenticides

Of necropsied large game mammals, 15 were tested for anticoagulant rodenticide exposure. Large game mammals were submitted from 11 of the 58 counties in California (Table 5). All age classes and sexes were represented in submitted carcasses.

Black bears accounted for the majority of large game mammals submitted with anticoagulant rodenticide exposure (Table 6). In total, 12 of the 15 (80%) large game mammals tested had exposure to one or more anticoagulant rodenticide and almost half of the tested animals (46.7%, 7/15) had exposure to two or more anticoagulant rodenticides regardless of first- or second generation (Figure 3). One sub-adult female from El Dorado County had exposure to five different anticoagulant rodenticides.

Diphacinone and brodifacoum were the most common analytes detected in tested liver samples (Figure 4). Coumachlor was not detected in any of the submitted liver samples.

None of the 12 exposures resulted in cases of anticoagulant rodenticide toxicosis.

Other Pesticide Exposure

Adipose from 14 black bears and one wild pig, and liver from one black bear from nine California counties were tested for exposure to the neurotoxic rodenticide, bromethalin (Table 7 and 8). Three of the tested black bears and the wild pig had detectable levels of bromethalin in the submitted samples. Of the four cases where bromethalin was detected, toxicosis was determined to be the cause of death in a young black bear from Kern County with a history of ataxia, circling, and incoordination. The bear was found deceased and submitted for postmortem examination and toxicology testing at the California Animal Health and Food Safety Lab in Tulare. Segmental mild vacuolation at the grey/white mater interface of the brain and chronic demyelination with Bungner's bands of motoric nerves fibers were

observed of the cauda equina nerve roots in the lumbar and sacral region with no other associated pathogens or injuries.

Two bears from El Dorado County were tested for exposure to organophosphates; no detectable levels were found.

A general toxicology panel (GMCS/LCMS) was performed on a black-tailed deer from Nevada County. Caffein was detected in the submitted liver sample.

Acetylcholinesterase activity was measured as within normal limits for two bears from Los Angeles and El Dorado County, and black-tailed deer from Tehama County.

Samples of blue-colored adipose (fat), muscle, and brain from an adult female black bear taken under a hunting permit in Sierra County were submitted for rodenticide testing. The sample was screened for the presence of anticoagulant rodenticide residues, and diphacinone was detected in all three of the tested samples. Exposure to other anticoagulant rodenticides or other pesticides cannot be ruled out, however, because liver is the preferred sample for anticoagulant rodenticide testing.

Table 5. Exposure prevalence and number of confirmed toxicosis cases of anticoagulant rodenticides in 15 tested wild large game mammals submitted to the Wildlife Health Laboratory in 2022 by county. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

County	No. Tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis
El Dorado	3	3	100.0	0
Humboldt	1	0	0	0
Kern	1	1	100.0	0
Los Angeles	1	1	100.0	0
Madera	1	1	100.0	0
Nevada	1	1	100.0	0
Placer	1	1	100.0	0
San Bernardino	2	2	100.0	0
Siskiyou	2	1	50.0	0
Tehama	1	0	0	0
Ventura	1	1	100.0	0
Total	**15**	**12**	**80.0**	**0**

Table 6. Exposure prevalence and number of confirmed toxicosis cases of anticoagulant rodenticides in 15 wild large game mammals submitted to the Wildlife Health Laboratory in 2022 by species. After a postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

Large Game Species	No. Tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis
Black bear	13	11	84.6	0
Black tailed deer/ Mule deer	1	0	0	0
Wild pig	1	1	1	0
Total	**15**	**12**	**80.0**	**0**

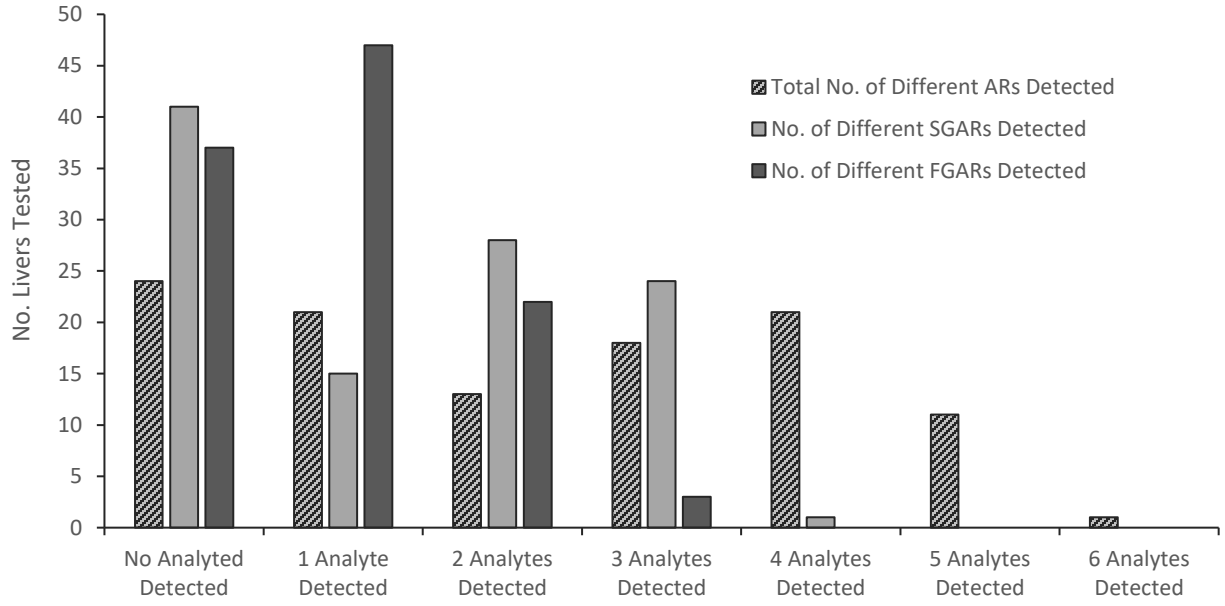

Figure 3. Number of anticoagulant rodenticide residues detected in the livers of 15 wild large game mammals submitted to the Wildlife Health Laboratory for postmortem examination in 2022. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

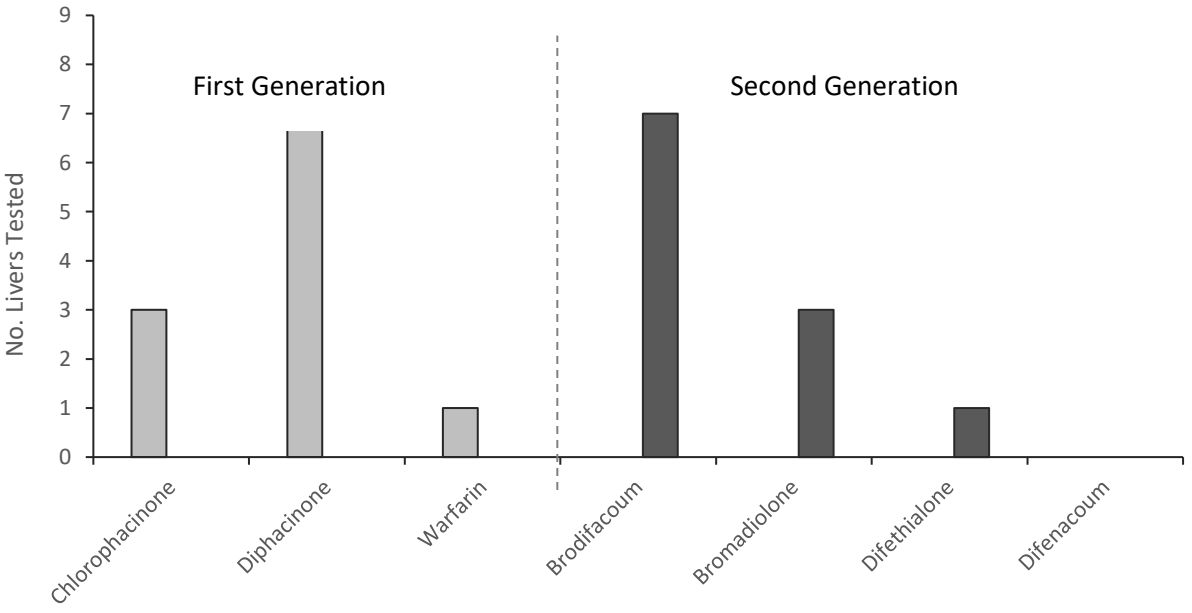

Figure 4. Anticoagulant rodenticide residues detected in the livers of 12 of the 15 tested wild large game mammals submitted to the Wildlife Health Laboratory in 2022. Anticoagulant rodenticides were not detected in 3 of the tested large game mammal livers. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

Table 7. Bromethalin exposure in wild large game mammals submitted to the Wildlife Health Laboratory in 2022 by county. Adipose or liver were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

County	No. Tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis
El Dorado	5	1	20.0	0
Kern	1	1	100.0	1
Los Angeles	1	0	0	0
Madera	1	1	100.0	0
Nevada	1	0	0	0
Placer	1	0	0	0
San Bernardino	2	1	50.0	0
Siskiyou	2	0	0	0
Ventura	1	0	0	0
Total	15	4	26.7	0

Table 8. Bromethalin exposure in wild large game mammals wildlife submitted to the Wildlife Health Laboratory in 2022 by species. Adipose or liver were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

Species	No. Tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis
Black bear	14	3	21.4	1
Wild pig	1	1	100.0	0
Total	**15**	**4**	**26.7**	**0**

American black bear | Eileen Hornbaker, USFWS

SMALL GAME & NON-GAME SUMMARY

The remains of 264 herptiles and mammals were submitted to the WHL for necropsy in 2022. This included samples and remains of animals primarily for specialized disease surveillance such as rabbit hemorrhagic disease virus (lagomorphs), snake fungal disease (snakes), and white-nose syndrome (bats).

Small game and non-game animals were submitted for various reasons by wildlife rehabilitators, members of the public, non-profit organizations, universities, CDFW staff and law enforcement, and other agencies. Wildlife rehabilitators made up 35% (92/264) of submissions, followed by CDFW (33%; Table 9). Toxicology testing was not performed on the herptiles. Therefore, the remainder of this section will address completed test results for mammals.

Table 9. Total number of wild small- and non-game mammal remains submitted to the Wildlife Health Laboratory in 2022 based on the primary submitter's affiliation. Many submissions that are non-public originated as a public report.

Submitter Affiliation	No. Small- and Non-Game Animals Submitted
Animal Control	9
CDFW	87
NGO/Non-Profit	3
Other	2
Other Government Agency	14
Private Biological Consultant	2
Public	21
Rehab/Zoo/Sanctuary	92
University Affiliate	34
Total	**264**

Anticoagulant Rodenticide Exposure & Toxicosis

Of necropsied mammals, 150 were tested for pesticide exposure but results are only available for 109 tested mammals at the time of this report. Sampled remains with final reports represent 38 of the 58 counties in California (Table 10). The remains for a juvenile mountain lion did not have a specified location. All age classes and sexes were represented.

Bobcats accounted for the largest percentage of mammal samples submitted to the WHL (Table 11). In total, 86 of the 109 (78.9%) mammals tested had exposure to one or more anticoagulant rodenticide and almost half of the tested animals had exposure to three or more anticoagulant rodenticides regardless of first- or second generation (Figure 5). One adult female bobcat from Orange County had exposure to six different anticoagulant rodenticides.

One of the 86 exposures (1.2%) resulted in a case of anticoagulant rodenticide toxicosis (Table 11). Anticoagulant rodenticide toxicosis was suspected in 3.5% (3/86) of tested animals with livers that had detectable residue exposure, however toxicosis could not be ruled in or out in due to advanced stages of decomposition, making gross and histological interpretation of the tissues difficult.

Brodifacoum, bromadiolone, and diphacinone were the most common analytes detected in liver samples (Figure 6). None of the tested samples had detectable levels of exposure to coumachlor.

Other Pesticide Exposure

One-hundred three wild non-game and small game mammals were tested for additional pesticides, including bromethalin, organophosphates and carbamates, neonicotinoids, pyrethroids, fipronil and fipronil sulfone.

Adipose or brain from 95 animals across 34 counties was tested for exposure to the neurotoxic rodenticide, bromethalin (Table 12). Twenty-two of the tested animals had exposure to bromethalin and 22.7% of those exposures resulted in mortality (2/22) or suspected mortality (3/22) (Tale 13). Advanced decomposition likely precluded the identification of any lesion(s) that may be associated with bromethalin toxicity in the long-tailed weasel with exposure. Further, it had a clinical history of depressed behavior with possible neurologic signs prior to death but these signs were not described in detail by the submitter. Thus, it is undetermined if exposure may have resulted in clinical signs and toxicosis.

A general toxicology panel (GMCS/LCMS) was performed on two raccoons from Sonoma and Tehama Counties. No toxic compounds were detected.

Vitamin D3 levels were tested in a mature adult female bobcat after tubular mineralization was observed in the vessels of her lungs and kidneys to rule out Vit-D3 toxicosis. Vitamin D3 levels were within normal limits and the mineralization observed is suspected to have been non-clinically significant.

Twelve North American river otters were tested for neonicontinoids, pythreins, fipronil and fipronil sulfone, and organophosphates, however final results are only available for five river otters at the time of this report. None of the toxic compounds were detected.

American badger | Tom Koerner, USFWS

Table 10. Exposure prevalence and number of confirmed toxicosis cases of anticoagulant rodenticides in the livers of 109 small game and non-game remains submitted to the Wildlife Health Laboratory for postmortem examination in 2022 by county. Livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA. In some cases, rodenticide residues were detected in the liver, but postmortem evidence could not confirm or exclude toxicosis due to advanced decomposition. Therefore, these diagnoses are reported as "undetermined" toxicosis.

County	No. tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis	No. Undetermined Toxicosis
Butte	1	1	100.0	0	0
Calaveras	2	1	50.0	0	0
Contra Costa	6	4	66.7	0	0
El Dorado	1	1	100.0	0	0
Fresno	1	0	0	0	0
Imperial	1	1	100.0	0	0
Inyo	1	1	100.0	0	0
Kern	8	7	87.5	0	0
Kings	1	1	100.0	0	0
Los Angeles	4	3	75.0	0	0
Mendocino	3	3	100.0	0	0
Merced	1	1	100.0	0	0
Modoc	1	0	0	0	0
Mono	7	6	85.7	0	0
Monterey	7	4	57.1	0	1
Napa	2	1	50.0	0	0
Nevada	3	3	100.0	0	0
Orange	6	6	100.0	0	0
Placer	2	2	100.0	0	0
Plumas	2	1	50.0	0	0
Riverside	2	2	100.0	0	0
Sacramento	3	3	100.0	0	1
San Benito	2	1	50.0	0	0
San Bernardino	2	2	100.0	0	0
San Diego	2	2	100.0	0	0
San Francisco	2	2	100.0	0	0
San Joaquin	3	0	0	0	0
San Luis Obispo	1	1	100.0	0	0
San Mateo	8	6	75.0	0	0
Santa Barbara	1	1	100.0	0	0
Santa Clara	3	3	100.0	1	0
Santa Cruz	3	3	100.0	0	0
Shasta	1	1	100.0	0	0
Sierra	2	1	50.0	0	0
Sonoma	8	8	100.0	0	0
Stanislaus	1	0	0	0	0
Tehama	1	1	100.0	0	0
Ventura	3	1	33.3	0	0

County	No. tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis	No. Undetermined Toxicosis
Not specified	1	1	100.0	0	1
Total	**109**	**86**	**78.9**	**1**	**3**

Table 11. Exposure prevalence and toxicosis of anticoagulant rodenticide residues detected in the livers of 109 small game and non-game mammals submitted to the Wildlife Health Laboratory for postmortem examination in 2022 by species. Livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA. In some cases, rodenticide residues were detected in the liver, but postmortem evidence could not confirm or exclude toxicosis due to advanced decomposition. Therefore, these diagnoses are reported as "undetermined" toxicosis.

Species	No. Tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis	No. Undetermined Toxicosis
Badger	1	1	100.0	0	0
Bobcat	38	33	86.8	0	0
Brush rabbit	5	0	0	0	0
Coyote	6	6	100.0	1	0
Eastern fox squirrel	1	0	0	0	0
Gray fox	13	12	92.3	0	2
Mountain Lion	19	17	89.5	0	1
Raccoon	7	3	42.9	0	0
Red fox	2	1	50.0	0	0
Ringtail	1	0	0	0	0
River otter	5	3	60.0	0	0
San Joaquin kit fox	8	7	87.5	0	0
Striped skunk	3	3	100.0	0	0
Total	**109**	**86**	**78.9**	**1**	**3**

American river otter | Keenan Adams, USFWS

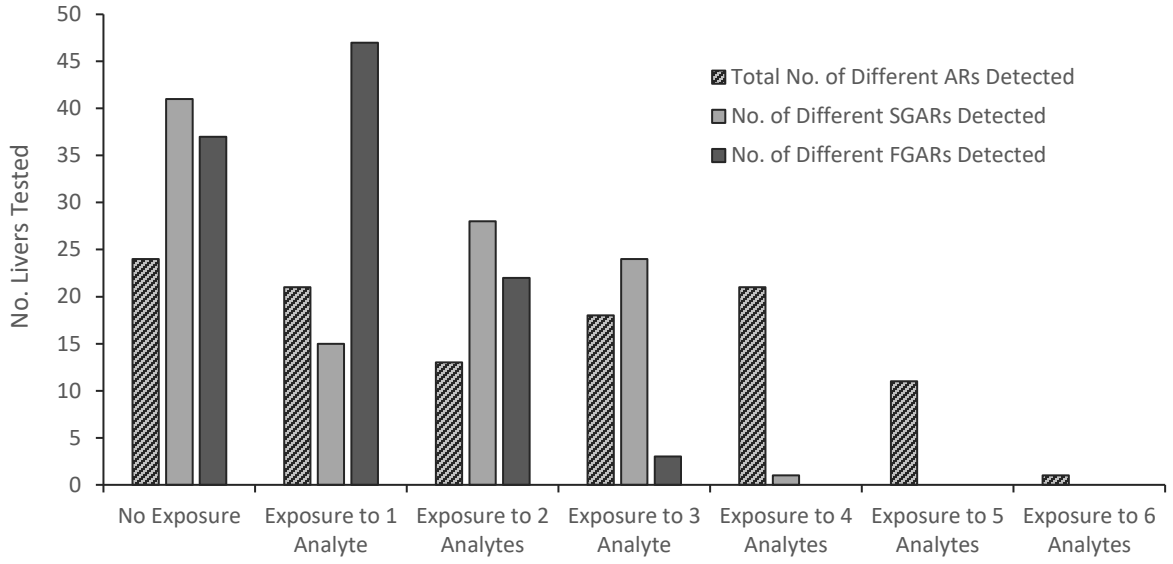

Figure 5. Number of anticoagulant rodenticide residues detected in the livers of 109 small game and non-game mammals submitted to the Wildlife Health Laboratory for postmortem examination in 2022. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

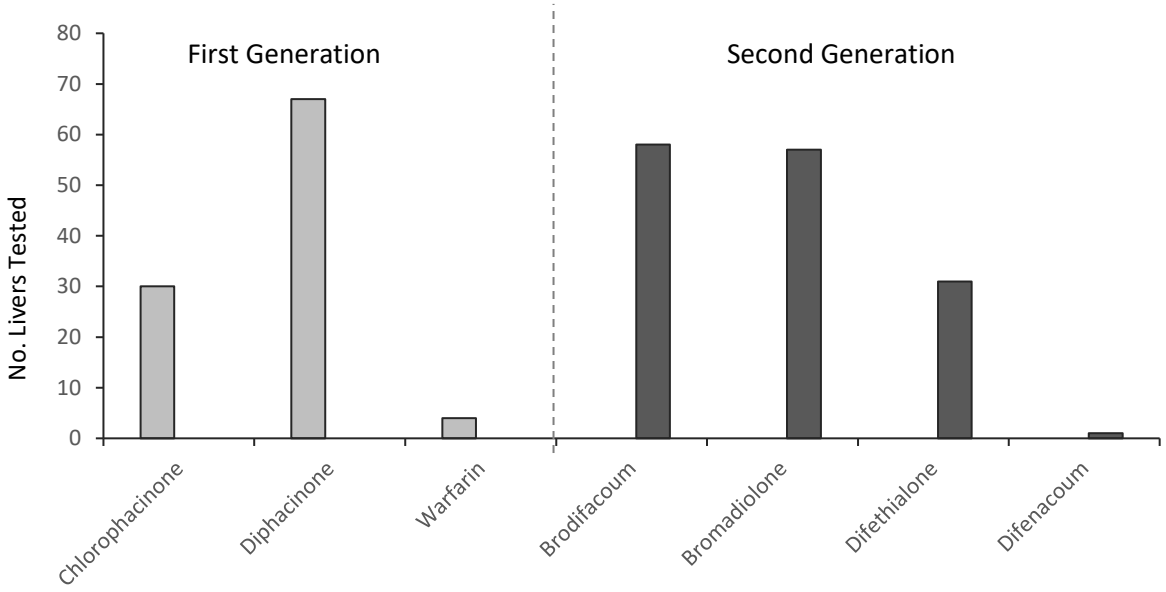

Figure 6. Anticoagulant rodenticide residues detected in the livers of wild small game and non-game mammals submitted to the Wildlife Health Laboratory for postmortem examination in 2022. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

Table 10. Bromethalin exposure and toxicosis in wild small game and non-game wildlife submitted to the Wildlife Health Laboratory in 2022 by county. Adipose or brain were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA. In some cases, bromethalin were detected in but antemortem and postmortem evidence could not confirm or exclude toxicosis due to advanced autolysis which may preclude histologically significant lesions or the inability to observe the animal while alive. Therefore, these diagnoses are reported as "undetermined toxicosis."

County	No. tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis	No. Undetermined Toxicosis
Butte	1	0	0	0	0
Calaveras	2	0	0	0	0
Contra Costa	3	1	33.3	0	0
El Dorado	1	0	0	0	0
Fresno	1	0	0	0	0
Imperial	1	0	0	0	0
Kern	7	0	0	0	0
Los Angeles	4	1	25.0	0	0
Marin	1	1	100.0	0	0
Mendocino	3	2	66.7	0	0
Modoc	1	1	100	0	0
Mono	5	0	0	0	0
Monterey	7	2	28.6	0	0
Napa	2	0	0	0	0
Nevada	3	0	0	0	0
Orange	6	3	50.0	0	0
Placer	2	1	50.0	0	0
Plumas	1	0	0	0	0
Riverside	2	0	0	0	0
Sacramento	1	0	0	0	0
San Benito	2	0	0	0	0
San Bernardino	2	0	0	0	0
San Diego	2	0	0	0	0
San Luis Obispo	1	0	0	0	0
San Mateo	7	2	28.6	0	0
Santa Barbara	2	0	0	0	0
Santa Clara	3	0	0	0	0
Santa Cruz	3	0	0	0	0
Shasta	1	0	0	0	0
Sierra	2	0	0	0	0
Sonoma	11	6	54.5	2	3
Tehama	1	0	0	0	0
Tulare	1	0	0	0	0
Ventura	2	1	50.0	0	0
Not specified	1	1	100.0	0	0
Total	**95**	**22**	**23.2**	**2**	**3**

Table 11. Bromethalin exposure and toxicosis in wild small game and non-game wildlife submitted to the Wildlife Health Laboratory in 2022 by species. Adipose or brain were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA. In some cases, bromethalin were detected in but antemortem and postmortem evidence could not confirm or exclude toxicosis due to advanced autolysis which may preclude histologically significant lesions or the inability to observe the animal while alive. Therefore, these diagnoses are reported as "undetermined toxicosis."

Species	No. tested	No. Exposed	Percent Exposed	No. Confirmed Toxicosis	No. Undetermined Toxicosis
Badger	2	0	0	0	0
Beaver	1	0	0	0	0
Bobcat	36	4	11.1	0	0
Coyote	6	1	16.7	0	0
Eastern fox squirrel	1	0	0	0	0
Eastern gray Squirrel	1	0	0	0	0
Gray fox	11	4	36.4	0	2
Mountain lion	17	6	35.3	0	0
Opossum	1	0	0	0	0
Raccoon	8	5	62.5	1	1
Red fox	1	1	100.0	0	0
Ringtail	1	0	0	0	0
San Joaquin kit fox	7	0	0	0	0
Striped skunk	2	1	50.0	1	0
Total	**95**	**22**	**23.2**	**2**	**3**

Raccoon | Bill Buchanan, USFWS

ADDITIONAL SURVEILLANCE

Poisoning of domestic dog

The CDFW was asked to investigate the mortality of a turkey vulture and two dogs on private property. The property owner reported finding her pet dog deceased outdoors near what appeared to be meat left out on a black tray that contained a blue substance and a white plastic container full of yellow liquid. The suspicious meat and liquid were placed along the fence line of the reporting party's property and a neighbor. The property owner buried her pet but found a deceased stray dog and turkey vulture on her property the following day. The property owner reported that the stray dog had foam coming from its mouth, a bloody nose, and vomit next to the dog. By the time CDFW LE officers were contacted, the suspicious meat and yellow liquid had been removed. Brain and stomach contents from the deceased stray dog were collected and submitted to the California Animal Health and Food Safety Lab in Davis. Methomyl, a carbamate insecticide, was detected in the stomach contents. Signs of carbamate toxicosis include hypersalivation, gastrointestinal hypermotility, abdominal cramping, vomiting, diarrhea, dyspnea, cyanosis, miosis, muscle fasciculations (in extreme cases, tetany followed by weakness and paralysis), and convulsions. Death usually results from respiratory failure and hypoxia due to bronchoconstriction leading to tracheobronchial secretion and pulmonary edema[2,3]. Pathological findings of toxicosis include dried saliva around the oral cavity and on other parts of the body that an animal may have touched with their mouth (e.g., forelegs), epistaxis, diffuse uveal congestion and hyphema, subcutaneous and muscular hemorrhage, food with carbamate in the stomach, microhemorrhages in the lower gastrointestinal tract, hemorrhagic pericardial content, diffuse cardiac hemorrhage, diffuse upper respiratory congestion and bilateral pulmonary congestion and edema of the lungs[3]. According to the U.S. Environmental Protection Agency, "There are no residential uses of methomyl. All methomyl products, except the bait formulations, are classified as Restricted Use Pesticides (RUPs). RUPs can only be used by or under the direct supervision of specially trained and certified applicators[4]." In California, a permit is required for the use and application of restricted materials, which includes carbamates such as methomyl[5].

Carbamate insecticides act similarly to organophosphate insecticides and inhibit cholinesterase activity, however cholinesterase activity levels in the brain were elevated. Elevate levels are of unknown clinical significance, however postmortem examination of the dog's remains were consistent with carbamate toxicosis (e.g., hypersalivation, vomiting, pulmonary edema, and hemorrhaging).

No toxic compounds were detected in the turkey vulture by gas chromatography - mass spectrometry (GC/MS) and liquid chromatography - mass spectrometry (LC/MS) organic chemical screens.

Evaluation of Assembly Bill 1788

A temporary moratorium was placed on the public sales and use of second generation anticoagulant rodenticides (SGARs) on January 1, 2021 under AB1788. Given the long half-lives of many SGARs and their ability to bioaccumulate in the livers of living animals, evaluating any immediate changes resulting from this temporary moratorium may be difficult. The CDFW proposed guidelines for monitoring the short-term, immediate effects of AB1788s as well as the continued long-term monitoring and surveillance of anticoagulant rodenticide exposure in non-target wildlife, especially given the special exceptions to this moratorium that still allow for SGAR use.

Short-term evaluation of the efficacy of AB1788 include looking at animals born or hatched after January 1, 2021 and cases of exposure and/or acute toxicosis. Our reasoning is that most wildlife born or hatched after implementation of AB1788 should not have exposure to SGARs (although there is a chance that mammals could have been exposed in utero[6-12]). A study by CDFW looking at anticoagulant rodenticide exposure in mountain lions found that cubs are less likely to have SGAR exposure when compared to adults[12] despite evidence of fetal exposure[6]. Further, we posit that wildlife that have died from acute toxicosis were likely recently exposed at concentrations large enough to cause coagulopathy and death rather than chronic exposure accumulating over time. It is important to note, however, that most wildlife have more than one analyte detected in their livers belonging to both first generation and second generation anticoagulant rodenticides. Additionally, there is no minimum threshold concentration indicative of anticoagulant rodenticide toxicosis and determining whether toxicosis was due to a first generation or second generation is difficult in the presence of multiple analytes and lack of information on the cumulative effects.

Twenty-one wild birds (n = 17) and mammals (n = 4) were determined to have a died, or suspected to have died, from acute coagulopathy due to anticoagulant rodenticide toxicosis (Table 14).

Thirty-one wild birds (n = 9: included < 1 yr old and 1.5 yr old) and mammals (n = 22: included <1 yr old) in calendar year 2022 had exposure to one or more anticoagulant rodenticide(s) (Table 15). Age and age classes were determined based on plumage and/or the presence of a bursa (for avians), dentition (mammals), and date of death since most species have reproductive seasons in which they predictively mate and produce offspring.


Great horned owl | Tom Koerner, USFWS


Bobcat | Grayson Smith, USFWS


Red-tailed hawk | Mark Bohn, USFWS

Table 14. Summary of cases of anticoagulant rodenticide (AR) toxicosis in non-target wildlife since the implementation of AB1788 on January 1, 2021. Livers from necropsied wildlife were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA. In some cases, rodenticide residues were detected in the liver, but postmortem evidence could not confirm or exclude toxicosis due to advanced decomposition. Therefore, these diagnoses are reported as "undetermined" toxicosis.

SGAR = second generation anticoagulant rodenticide, FGAR = first generation anticoagulant rodenticide

Date of Death	Species	County	Sex	Age Class	AR Toxicosis	No. SGARs Detected	No. FGARS Detected
AVIAN SUBMISSIONS							
1/18/2022	Red-tailed hawk	Santa Clara	F	Juvenile	Yes	1	0
1/20/2022	Great horned owl	Marin	F	Adult	Yes	3	1
2/3/2022	Barn owl	Ventura	M	Adult	Suspect	3	0
2/14/2022	Red-shouldered hawk	Ventura	M	Adult	Yes	2	0
4/4/2022	Great horned owl	Marin	M	Adult	Yes	3	1
2/10/2022	Great horned owl	Santa Cruz	F	Adult	Yes	3	1
3/31/2022	Great horned owl	Los Angeles	M	Juvenile	Yes	0	1
7/25/2022	Great horned owl	Los Angeles	F	Adult	Yes	3	2
7/26/2022	Great horned owl	Los Angeles	M	Adult	Yes	2	1
7/20/2022	Red-shouldered hawk	Sonoma	F	Adult	Yes	2	0
10/2/2022	Great horned owl	Los Angeles	M	Juvenile	Yes	3	2
10/5/2022	Great horned owl	Contra Costa	M	Juvenile	Yes	3	1
10/21/2022	Great horned owl	San Diego	M	Juvenile	Yes	2	1
4/25/2022	Great horned owl	San Bernardino	F	Adult	Suspect	1	0
11/14/2022	Great horned owl	Santa Clara	F	Adult	Yes	3	1
12/13/2022	Barn owl	San Mateo	F	Juvenile	Yes	2	1
11/15/2022	Great horned owl	Kern	M	Juvenile	Yes	3	0
MAMMAL SUBMISSIONS							
1/6/2022	Coyote	Santa Clara	F	Adult	Yes	2	3
2/10/2022	Gray Fox	Sacramento	M	Adult	Suspect	1	1
10/30/2022	Mountain Lion	Not specified	M	Cub	Suspect	3	1
12/16/2022	Gray Fox	Monterey	M	Adult	Suspect	0	1

Table 15. Summary of cases of anticoagulant rodenticide (AR) exposure in non-target wildlife born or hatched after the implementation of AB1788 on January 1, 2021. Age classes were determined based on plumage, dentition, and reproductive phenology of the species. Livers from necropsied wildlife were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA. In some cases, rodenticide residues were detected in the liver, but postmortem evidence could not confirm or exclude toxicosis due to advanced decomposition. Therefore, these diagnoses are reported as "undetermined" toxicosis.

SGAR = second generation anticoagulant rodenticide, FGAR = first generation anticoagulant rodenticide

Date of Death	Species	County	Sex	Age Class	AR Toxicosis	No. SGARs Detected	No. FGARS Detected
AVIAN SUBMISSIONS							
1/14/2022	Golden eagle	San Luis Obispo	M	Juvenile	No	0	1
1/18/2022	Red-tailed hawk	Santa Clara	F	Juvenile	Yes	1	0
3/31/2022	Great horned owl	Los Angeles	M	Juvenile	Yes	0	1
4/26/2022	Great horned owl	Ventura	F	Juvenile	No	0	0
5/9/2022	Great horned owl	Sonoma	M	Juvenile	No	0	0
10/2/2022	Great horned owl	Los Angeles	M	Juvenile	Yes	3	2
10/5/2022	Great horned owl	Contra Costa	M	Juvenile	Yes	3	1
10/21/2022	Great horned owl	San Diego	M	Juvenile	Yes	2	1
11/16/2022	Great horned owl	Santa Clara	M	Juvenile	No	1	0
12/13/2022	Barn owl	San Mateo	F	Juvenile	Yes	2	1
11/15/2022	Great horned owl	Kern	M	Juvenile	Yes	3	0
MAMMAL SUBMISSIONS							
8/30/2022	Black bear	San Bernardino	Male	1st Year	No	0	1
8/30/2022	Black bear	San Bernardino	Male	1st Year	No	1	1
10/4/2022	Black bear	El Dorado	Female	1st Year	No	1	1
11/10/2022	Black bear	Ventura	Male	1st Year	No	1	0
11/21/2022	Black bear	El Dorado	Male	1st Year	No	1	0
1/20/2022	Coyote	Orange	M	Juvenile	No	3	1
Found 2022	Mountain lion	El Dorado	M	Juvenile	No	0	1
1/19/2022	Coyote	Mono	F	Yearling	No	3	1
2/19/2022	Bobcat	Monterey	F	Juvenile	No	0	1
3/4/2022	Striped skunk	San Francisco	F	Juvenile	No	2	0
3/22/2022	Bobcat	San Mateo	F	Yearling	No	2	1
5/25/2022	Red fox	Contra Costa	M	Pup	No	0	1
7/5/2022	Mountain lion	Nevada	F	Yearling	No	2	1
8/4/2022	Gray fox	Contra Costa	F	Juvenile	No	1	3
9/4/2022	Bobcat	Placer	M	Yearling	No	3	2
10/3/2022	Striped skunk	Plumas	M	Juvenile	No	0	1
10/12/2022	Mountain lion	Orange	F	Cub	No	2	2
10/30/2022	Mountain lion	Not specified	M	Cub	Suspect	3	1
10/18/2022	Mountain lion	Sonoma	M	Cub	No	2	1
11/30/2022	Raccoon	Sonoma	F	Juvenile	No	0	0
12/19/2022	Gray fox	Shasta	F	Juvenile	No	0	1
12/26/2022	San Joaquin kit fox	Kern	F	Juvenile	No	1	1

LITERATURE CITED

1. van den Brink, N.W., Elliott, J.E., Shore, R.F. and Rattner, B.A., 2018. Anticoagulant rodenticides and wildlife. Springer, Cham.

2. Online Merck Veterinary Manual. "Carbamate toxicosis in animals." https://www.merckvetmanual.com/toxicology/insecticideand-acaricide-organic-toxicity/carbamate-toxicosis-in-animals. Accessed November 4, 2022.

3. Pivariu, D., Oros, A. N., Tabaran, F., Gal, A., Martonos, C., & Nagy, A. L. (2020). Intentional Carbofuran poisoning in 7 dogs. BMC veterinary research, 16(1), 1-9.

4. U.S. Environmental Protection Agency. "Methomyl." https://www.epa.gov/ingredients-used-pesticide-products/methomyl. Accessed on November 7, 2022.

5. California Department of Pesticide Regulation. "Restricted Use Materials." https://www.cdpr.ca.gov/docs/enforce/permitting.htm. Accessed on November 8, 2022.

6. Rudd, J. L., McMillin, S. C., Kenyon Jr, M. W., Clifford, D. L., & Poppenga, R. H. (2020). Brodifacoum and Diphacinone Exposure in Fetal Tissue of a Pregnant Mountain Lion in California. Presented at the Vert Pest Conf. Santa Barbara, CA.

7. Serieys, L. E., Armenta, T. C., Moriarty, J. G., Boydston, E. E., Lyren, L. M., ... & Riley, S. P. (2015). Anticoagulant rodenticides in urban bobcats: exposure, risk factors and potential effects based on a 16-year study. Ecotoxicology, 24(4), 844-862.

8. Gabriel, M. W., Woods, L. W., Poppenga, R., Sweitzer, R. A., Thompson, C., ... & Clifford, D. L. (2012). Anticoagulant rodenticides on our public and community lands: spatial distribution of exposure and poisoning of a rare forest carnivore. PloS one, 7(7), e40163.

9. Munday, J. S., & Thompson, L. J. (2003). Brodifacoum toxicosis in two neonatal puppies. Veterinary pathology, 40(2), 216-219.

10. Fitzgerald, S. D., Martinez, J., & Buchweitz, J. P. (2018). An apparent case of brodifacoum toxicosis in a whelping dog. Journal of Veterinary Diagnostic Investigation, 30(1), 169-171.

11. Zakian, A., Mami, S., Nouri, M., Jalali, S. M., & Tehrani-Sharif, M. (2019). Brodifacoum toxicosis and abortion in an Arabian mare. In Veterinary Research Forum, 10(2), 173. Faculty of Veterinary Medicine, Urmia University, Urmia, Iran.

12. Rudd, J. L., McMillin, S. C., Kenyon Jr, M. W., Clifford, D. L., & Poppenga, R. H. (2018). Prevalence of first and second-generation anticoagulant rodenticide exposure in California mountain lions (*Puma concolor*). In Proc. Vert Pest Conf.