PESTICIDE EXPOSURES & MORTALITIES IN WILDLIFE

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

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Wildlife Health Laboratory
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2020 SUMMARY OF PESTICIDE EXPOSURES & MORTALITIES IN WILDLIFE

By Jaime Rudd, Krysta Rogers, & Nicholas Shirkey

With contributions from Vicky Monroe, Alex Heeren, Dr. Emma Lantz, Dr. Megan Moriarty, Dr. Deana Clifford, Jessica Nelson, & Kelsey Clark

PREPARED BY THE WILDLIFE HEALTH LABORAOTRY OF THE CALIFORNIA DEPARMTMENT 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 2020 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 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 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 for cause of death studies. 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 32-hours of collection, they are stored in a -20°C freezer until examination. Prior to necropsy, carcasses are thawed at 4°C or room temperature. Sex, age class, body condition and, when possible, the cause of death is determined. Examination includes 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

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 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].

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

AVIAN SUMMARY

According to CDFW records at the time of this report, 650 birds were submitted to the WHL for necropsy and/or toxicology testing in the year 2020. Approximately 581 birds have been necropsied, with 69 carcasses still pending necropsy or toxicology results.

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.

Anticoagulant Rodenticide Exposure & Toxicosis

Of the 581 necropsied birds, 53 were tested for pesticide exposure. Tested birds represent 74% (43/58) of California counties (Table 2). All age classes and sexes were represented in submitted carcasses.

Raptors accounted for 87% of birds tested for pesticides and were the largest group to have anticoagulant rodenticide exposure and/or toxicosis (Table 3). In total, 72% (33/46) of raptors tested had exposure to one or more anticoagulant rodenticide and 16 of the 33 (49%) were toxicosis cases.

Two common ravens, one American crow and four Canada geese were screened for anticoagulant rodenticides (Table 3). The common ravens were from a group of four birds found dead in San Luis Obispo County but only two were submitted for necropsy. The cause of death for both ravens was anticoagulant rodenticide toxicosis, primarily from brodifacoum. The American crow was collected in Yolo County and no anticoagulant rodenticides were detected in the submitted liver sample. The Canada geese were harvested by hunters in Contra Costa County. The liver of one goose with blue-colored adipose (fat) tested positive for diphacinone while three other geese submitted from the same area were negative (and lacked blue colored adipose).

More than half of the exposed birds had two or more second generation anticoagulant rodenticides detected in the submitted liver sample (Figure 1). Overall, more than half of the tested animals had exposure to three or more anticoagulant rodenticides regardless of first- or second generation. Brodifacoum, bromadiolone, and diphacinone were the most common analytes detected in liver samples (Figure 2). None of the tested bird samples had detectable levels of exposure to warfarin, difenacoum, or coumachlor.

Table 1. Total number of wild bird remains submitted to the Wildlife Health Laboratory for necropsy in 2020 based on the primary submitter's affiliation. Many submissions that are non-public originated as a public report.

Submitter Affiliation	No. Birds Submitted
CDFW	93
NGO/Non-Profit	8
Other Government Agency / Military	128
Private Consultant / Energy	30
Public	16
Rehab / Zoo / Sanctuary	361
University Affiliate	14
Total	**650**

Table 2. Exposure prevalence and number of confirmed toxicosis cases of anticoagulant rodenticides in 53 wild birds submitted to the Wildlife Health Laboratory in 2020 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. Birds Tested	No. Birds w/Exposure	Exposure Prevalence	No. Confirmed Toxicosis
Alameda	1	0	0	0
Contra Costa	8	3	37.5	2
Los Angeles	6	3	50.0	3
Marin	1	1	100	0
Monterey	2	2	100	0
Napa	2	2	100	0
Riverside	2	2	100	1
Sacramento	2	2	100	1
San Benito	2	0	0	0
San Bernardino	1	0	0	0
San Diego	2	2	100	1
San Luis Obispo	8	8	100	7
San Mateo	2	2	100	1
Santa Barbara	2	0	0	0
Santa Clara	1	1	100	0
Shasta	1	1	100	0
Solano	1	1	100	0
Sonoma	3	2	66.7	0
Trinity	1	0	0	0
Tulare	1	1	100	0
Ventura	2	2	100	2
Yolo	2	2	100	0
Total	**53**	**37**	**69.8**	**18**

Avian mortalities attributed to toxicosis had a range of residue values detected in livers from trace to 1000 ppb, while other birds had trace to 3400ppb and did not have evidence of coagulopathy and toxicosis (e.g., the hunter-harvest Canada goose; Table 4).

Other Pesticides

Other pesticide-related investigations involved two incidents of mass-mortalities including: 1) more than 50 red-winged blackbirds and Brewer's blackbirds in Solano County, and 2) over 150 wild birds of various species (e.g., red-winged blackbirds, tricolored blackbirds, brown-headed cowbirds, and European starlings) in Kern County. Strychnine was confirmed in birds from Solano County. Strychnine was not detected in the birds from Kern County.

Table 3. Exposure prevalence and number of confirmed toxicosis cases of anticoagulant rodenticides in 53 wild birds submitted to the Wildlife Health Laboratory in 2020 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.

Species	No. Tested	No. Exposure	Exposure Prevalence	No. Confirmed Toxicosis
American crow	1	0	0	0
American kestrel	1	0	0	0
Bald eagle	3	1	33	0
Barn owl	16	7	44	4
Canada goose	4	1	25	0
Common raven	2	2	100	2
Golden eagle	1	1	100	0
Great-horned owl	11	11	100	7
Red-shouldered hawk	2	2	100	0
Red-tailed hawk	5	5	100	4
Spotted owl	2	2	100	0
Swainson's hawk	2	1	50	0
Turkey vulture	3	3	100	1
Total	**53**	**36**	**68**	**18**

Table 4. Range of anticoagulant rodenticide residue values detected in the livers of 53 wild bird remains submitted to the Wildlife Health Laboratory for postmortem examination in 2020. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA. Ranges are expressed in parts per billion (ppb). A trace amount indicates that the analyte was present in the tested sample but at a concentration below the stated reporting limit and cannot be accurately quantitated. BRD: brodifacoum, BRM: bromadiolone, CHL: chlorophacinone, DIF: difethialone, DIPH: diphacinone. Warfarin, difenacoum, and coumachlor were not detected in any of the samples and therefore not included in the table. Note that there are no minimum "threshold" concentrations of residues detected in the liver that could be an indicator for toxicosis.

Species	No. Tested	No. Exposed	BRD	BRM	CHL	DIF	DIPH
Bald eagle	**3**	**1**	Trace	Trace	0	0	0
Barn owl	**16**	**7**	0 - 310	0 - 820	0	0 - 490	0
Canada goose	**4**	**1**	0	0	0	0	0 - 3400
Common raven	**2**	**2**	920 - 1000	0	Trace	0 - Trace	0 - 110
Golden eagle	**1**	**1**	88	Trace	0	0	0
Great-horned owl	**11**	**11**	0 - 980	Trace - 540	Trace	0 - 240	0 - 250
Red-shouldered hawk	**2**	**2**	Trace - 610	0 - 820	0	0	0
Red-tailed hawk	**2**	**5**	Trace - 910	0	0	Trace to 1000	0
Spotted owl	**2**	**2**	Trace	0	0	0 - Trace	0
Swainson's hawk	**2**	**1**	860	Trace	0	Trace	0
Turkey vulture	**3**	**3**	500 - 180	0	0	Trace - 290	0

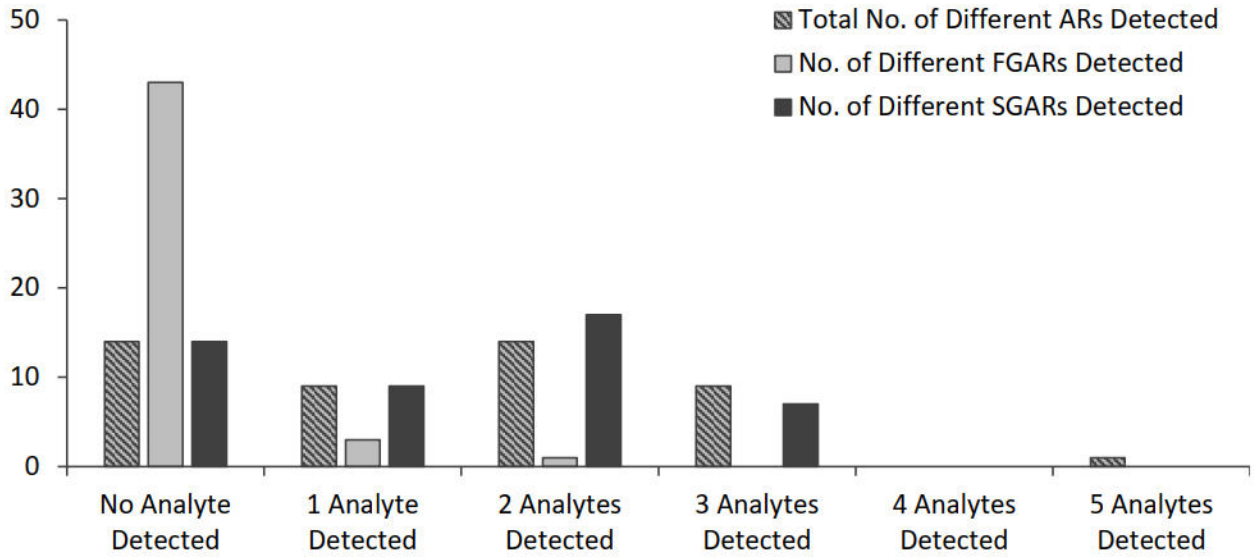

Figure 1. Number of anticoagulant rodenticide residues detected in the livers of 53 wild birds submitted to the Wildlife Health Laboratory for postmortem examination in 2020. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

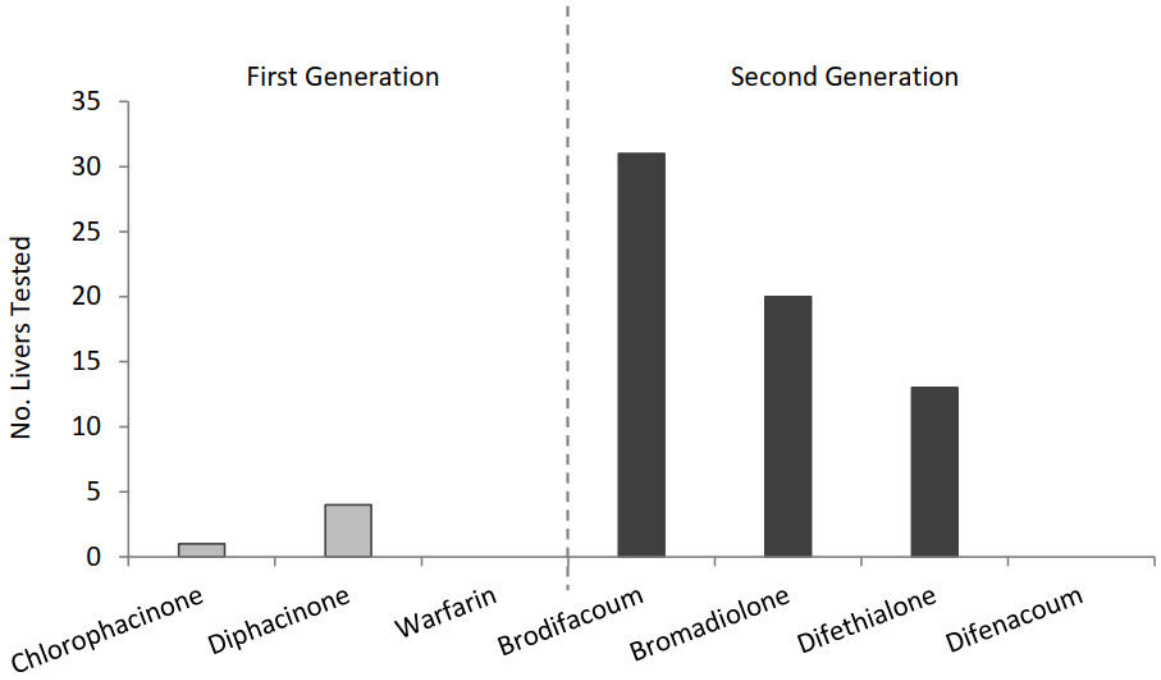

Figure 2. Anticoagulant rodenticide residues detected in the livers of 47 of the 53 tested wild birds submitted to the Wildlife Health Laboratory in 2020. Anticoagulant rodenticides were not detected in 6 of the tested bird livers. After postmortem examination, livers were submitted for toxicology testing to the California Animal Health and Food Safety Laboratory in Davis, CA.

LARGE GAME SUMMARY

The remains of 74 large game mammals were submitted to the WHL for necropsy and/or toxicology testing in the year 2020 (Table 5).

Table 5. Number of wild large game remains submitted to the Wildlife Health Laboratory in 2020 by species and sub-species.

Species	No. Large Game Animals Submitted
Black bear	20
Black-tailed deer	31
California mule deer	5
Desert bighorn sheep	1
Peninsular bighorn sheep	2
Rocky mountain mule deer	1
Roosevelt elk	2
Southern mule deer	3
Tule elk	8
Wild pig	1
Total	**74**

Eighty-six percent (64/74) of the large game carcasses were submitted by the CDFW and other agencies, while the public and wildlife rehabilitators made up roughly 14% (10/74) of submissions (Table 6). However, it should be noted that public reports represent the original source for most CDFW submissions.

Large game mammals were submitted from 39 of the 58 counties in California, and one animal came from the state of Nevada (Table 7). All age classes and sexes were represented in submitted carcasses.

Table 6. Total number of wild large game remains submitted to the Wildlife Health Laboratory for postmortem examination in 2020 based on the primary submitter's affiliation. Most submissions that are non-public originated as a public report.

Submitter Affiliation	No. Large Game Animals Submitted
CDFW	54
Rehab	8
Other Government Agency	10
Public	2
Total	**74**

Anticoagulant Rodenticides

Of necropsied bears, one adult female black bear from Fresno County and an adult male black bear from Shasta County were tested for anticoagulant rodenticide exposure. A single anticoagulant rodenticide, diphacinone (710 ppb) was detected in the liver of the Fresno County. Anticoagulant rodenticide residues were not detected in the liver of the Shasta County bear. Toxicosis was not observed in either animal.

Table 7. Total number of wild large game mammals remains submitted to the Wildlife Health Laboratory for postmortem examination in 2020 by county.

County	No. of Large Game Animals Submitted
Alameda	1
Amador	2
Butte	2
Calaveras	1
Colusa	2
Contra Costa	1
Del Norte	2
El Dorado	6
Fresno	1
Humboldt	3
Kern	2
Lake	2
Los Angeles	1
Madera	1
Marin	7
Mendocino	2
Merced	1
Modoc	1
Mono	1
Napa	1
Nevada	1
Placer	3
Plumas	1
Riverside	2
Sacramento	1
San Bernardino	1
San Diego	2
San Luis Obispo	2
Santa Clara	1
Santa Cruz	2
Shasta	1
Sierra	1
Siskiyou	4
Sonoma	3
Tehama	2
Tulare	2
Tuolumne	1
Ventura	1
Yolo	2
Washoe, NV	1
Total	**74**

Other Pesticides

A sample of blue-colored adipose (fat) from a black-tailed deer taken under a hunting permit in San Luis Obispo County was submitted for toxicology testing. The sample was screened for the presence of anticoagulant rodenticide residues, as well as a general toxicology screen, but no analytes were detected. Exposure to anticoagulant rodenticides or other pesticides cannot be ruled out, however, because adipose is not the preferred sample for anticoagulant rodenticide testing. The blue-colored dye observed in the fat was identified as "Solvent Blue 36" via mass spectroscopy. This dye has a strong affinity for animal fat and is a common colorant to help indicate where products have been applied (e.g., turf and lawn treatment products, tissue staining in histology, etc.).

General toxicology panels (GMCS/LCMS) were performed on two black bears – the aforementioned bear from Fresno County and a second bear from Kern County. Testing was negative in the bear from Fresno County, but caffeine was identified as an analyte in the Kern County bear. Acetylcholinesterase activity was measured as within normal limits for the Kern County bear. In the Fresno County bear, acetylcholinesterase activity was decreased, however, no evidence of organophosphate or carbamate poisoning was found.

SMALL GAME AND NON-GAME SUMMARY

There were 316 herpetiles and mammals submitted to the WHL for necropsy and/or toxicology testing in 2020. This included remains submitted primarily for specialized disease surveillance such as rabbit hemorrhagic disease virus (lagomorphs), snake fungal disease (snakes), and white-nose syndrome (bats). Approximately 250 animals have been necropsied, with 40 samples pending toxicology results.

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. CDFW submissions made up 31% of submissions, followed by other government agencies (25%), and wildlife rehabilitators (18%; Table 8).

The decomposed remains of two California tiger salamanders were submitted for examination, however, toxicology testing was not performed due to the absence of organs or advanced decomposition. Therefore, the remainder of this section will address test results for mammals.

Table 8. Total number of small game and non-game remains submitted to the Wildlife Health Laboratory for postmortem examination in 2020 based on the primary submitter's affiliation. Most submissions that were non-public originated as a public report.

Submitter Affiliation	No. Small and Non-Game Animals Submitted
CDFW	98
NGO / Non-Profit	10
Other	1
Other Government Agency	80
Private Biological Consultant	15
Public	24
Rehab / Zoo / Sanctuary	57
University Affiliate	31
Total	**316**

Anticoagulant Rodenticide Exposure & Toxicosis

Of necropsied mammals, 104 were tested for pesticide exposure across 46 California counties and submitted animal remains represent 79% of the counties in California (Table 9). All age classes and sexes were represented.

Mountain lions and coyotes accounted for the largest percentage of mammal samples submitted with anticoagulant rodenticide exposure (Table 10). In total, 71 of 104 (68.3%) mammals tested had exposure to one or more anticoagulant rodenticide and more than half of the tested animals had exposure to three or more anticoagulant rodenticides regardless of first- or second generation (Figure 3). One coyote had exposure to six different anticoagulant rodenticides.

Six of the 71 exposures resulted in cases of anticoagulant rodenticide toxicosis (Table 10). In eight out of 71 animals with livers that had detectable residue exposure (11.3%),

Table 9. Exposure prevalence and number of confirmed toxicosis cases of anticoagulant rodenticides in the livers of 104 small game and non-game remains submitted to the Wildlife Health Laboratory for postmortem examination in 2020 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	Exposure Prevalence	No. Confirmed Toxicosis	No. Undetermined Toxicosis
Alameda	2	2	100	0	0
Amador	1	0	0	0	0
Butte	1	1	100	1	0
Contra Costa	4	4	100	0	0
Humboldt	3	1	33	0	0
Kern	9	6	67	0	1
Lake	1	1	100	0	1
Los Angeles	8	8	100	0	2
Marin	2	1	50	0	0
Mono	3	3	100	0	0
Monterey	2	2	100	0	0
Napa	4	1	25	0	0
Orange	1	1	100	0	0
Plumas	1	1	100	0	0
Riverside	4	1	25	0	0
Sacramento	5	3	60	1	1
San Benito	2	2	100	0	0
San Bernardino	5	3	60	1	0
San Diego	3	3	100	0	0
San Joaquin	1	1	100	1	0
San Luis Obispo	3	2	67	0	1
San Mateo	2	1	50	0	0
Santa Barbara	2	1	50	0	0
Santa Clara	8	6	75	0	0
Santa Cruz	9	9	100	0	1
Shasta	1	1	100	0	0
Siskiyou	1	0	0	0	0
Solano	3	1	33	0	0
Sonoma	3	2	67	0	1
Trinity	1	0	0	0	0
Ventura	4	3	75	2	0
Yolo	5	0	0	0	0
Total	**104**	**71**	**68**	**6**	**8**

Table 10. Exposure prevalence and toxicosis of anticoagulant rodenticide residues detected in the livers of 104 small game and non-game mammals submitted to the Wildlife Health Laboratory for postmortem examination in 2020 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.

Small Game and Non-Game Species	No. Tested	No. Exposed	Exposure Prevalence	No. Confirmed Toxicosis	No. Undetermined Toxicosis
Audubon's desert cottontail	2	1	50	1	0
Bobcat	14	13	93	0	2
Brazilian free-tailed bat	5	0	0	0	0
Coyote	16	14	88	2	1
Desert kit fox	5	2	40	0	0
Eastern fox squirrel	2	1	50	0	0
Gray fox	13	11	85	1	2
Long-tailed weasel	2	0	0	0	0
Mountain lion	16	14	88	1	1
Muskrat	1	0	0	0	0
Opossum	3	0	0	0	0
Raccoon	5	5	100	0	1
River otter	1	0	0	0	0
San Joaquin antelope squirrel	1	0	0	0	0
San Joaquin kit fox	3	1	33	0	0
Striped skunk	13	8	62	0	1
Western gray squirrel	1	0	0	0	0
Yellow-bellied marmot	1	1	100	1	0
Total	**104**	**71**	**68**	**6**	**8**

anticoagulant rodenticide toxicosis could not be confirmed from gross postmortem examination, microscopic evaluation of the tissues (histology), and toxicology, but toxicosis could not be ruled out (Table 10). This usually occurs when the remains are in 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 4). None of the tested samples had detectable levels of exposure to coumachlor.

Similar to avian submissions, mortalities attributed to toxicosis had a range of residue values detected in lives from trace to 6400 ppb, while other animals had trace to 2100 ppb detected yet did not have evidence of coagulopathy and toxicosis (Table 11).

Table 11. Range of anticoagulant rodenticides residue values detected in the livers of wild small game and non-game remains submitted to the Wildlife Health Laboratory for postmortem examination in 2020. Ranges are expressed in parts per billion (ppb). A trace amount indicates that the analyte was present in the tested sample, but at a concentration below the stated reporting limit and cannot be accurately quantitated. BRD: brodifacoum, BRM: bromadiolone, CHL: chlorophacinone, DIF: difethialone, DIPH: diphacinone, WAR: warfarin, and DFN; difenacoum. Coumachlor was not detected in any of the samples. Note that there are no "threshold" concentrations of residues detected in either blood or liver that could be an indicator for toxicosis.

Species	No. Tested	No. Exposed	BRD	BRM	CHL	DIF	DIPH	WAR	DFN
Audubon's desert cottontail	2	1	0	0	0	0	0 - 340	0	0
Bobcat	14	13	0 - 250	0 - 1100	0 - Trace	0 - 560	0 - 380	0	0
Brazilian free-tailed bat	5	0	0	0	0	0	0	0	0
Coyote	16	14	0 - 1100	0 - >2500	0 - 82	0 - 470	0 - 670	0	0 - Trace
Desert kit fox	5	2	0 - Trace	0	0	0 - Trace	0 - 68	0	0
Eastern fox squirrel	2	1	0	0	0	0	0 - 6400	0	0
Gray fox	13	11	0 - 1400	0 - 1200	0	0 - 670	0 - 430	0	0 - Trace
Long-tailed weasel	2	0	0	0	0	0	0	0	0
Mountain lion	16	14	0 - 320	0 - 2100	0 - Trace	0 - 260	0 - 800	0 - Trace	0
Muskrat	1	0	0	0	0	0	0	0	0
Opossum	3	0	0	0	0	0	0	0	0
Raccoon	5	5	0 - 220	0 - 110	0 - Trace	0 - 160	0 - 430	0	0 - Trace
River otter	1	0	0	0	0	0	0	0	0
San Joaquin antelope squirrel	1	0	0	0	0	0	0	0	0
San Joaquin kit fox	3	1	0 - Trace	0	0	0	0	0	0
Striped skunk	13	8	0 - 100	0 - 280	0	0 - 1100	0 - Trace	0	0 - Trace
Western gray squirrel	1	0	0	0	0	0	0	0	0
Yellow-bellied marmot	1	1	0	0	0	0	3900	0	0

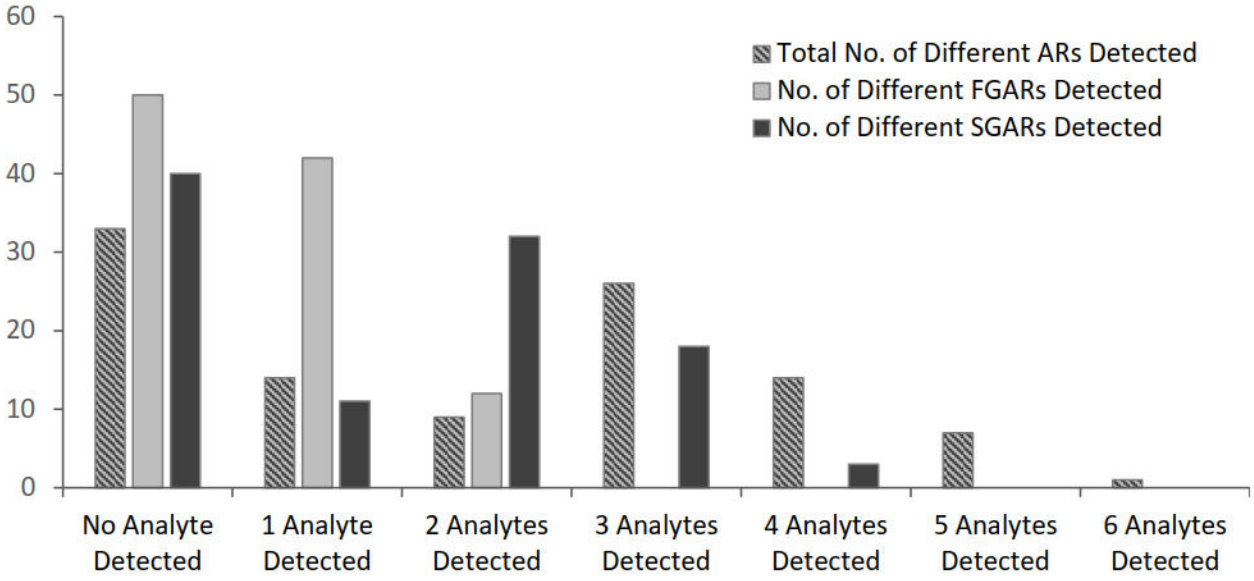

Figure 3. Number of anticoagulant rodenticide residues detected in the livers of 104 small game and non-game mammals submitted to the Wildlife Health Laboratory for postmortem examination in 2020.

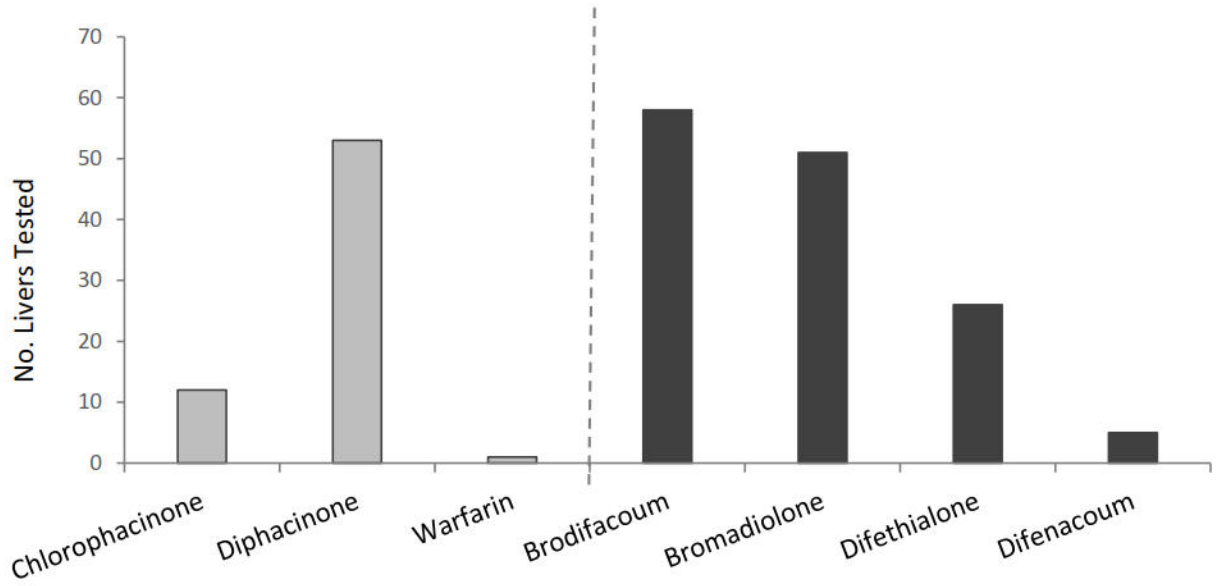

Figure 4. Anticoagulant rodenticide residues detected in the livers of wild small game and non-game mammals submitted to the Wildlife Health Laboratory for postmortem examination in 2020.

Other Pesticide Exposure

Thirty-nine mammals were tested for additional pesticides, including bromethalin, strychnine, ethylene glycol, organophosphates, and carbamates.

Adipose or brain from 24 animals was tested for exposure to the neurotoxic rodenticide, bromethalin (Table 12) with results still pending on five individuals at the time of this report. Approximately 31% (6/19) of the tested mammals with results had exposure to bromethalin and 66.7% (4/6) of those exposures, resulted in mortality. A bobcat and mountain lion with pathological findings consistent with vehicular trauma were both positive for exposure to bromethalin. The extensive head injury to both animals precluded the identification of any lesion that may be associated with bromethalin toxicity, thus it is unclear if exposure may have resulted in toxicosis.

One gray fox from Sacramento County was tested for another neurotoxic rodenticide, strychnine; test results were negative.

Two coyotes from Monterey and Los Angeles counties died from ethylene glycol toxicosis.

Heavy metal and acetylcholinesterase activity were measured as within normal limits on five Brazilian free-tailed bats (Yolo County), one coyote (Alameda County) and four bobcats from Sacramento (n = 1), Los Angeles (n = 2), and San Benito (n = 1) counties.

General toxicology panels (GMCS/LCMS) were performed on two mountain lions – one from San Diego and one from Lake County – and results were negative.

Table 22. Bromethalin exposure and toxicosis in wild small game and non-game wildlife submitted to the Wildlife Health Laboratory in 2020 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	Small Game and Non-Game Species	Bromethalin Exposure	Bromethalin Toxicosis
Contra Costa	Striped Skunk	Pending	Pending
Humboldt	Gray fox	Pending	Pending
	Long-tailed weasel	No	No
	Mountain lion	No	No
Kern	Gray fox	No	No
	Raccoon	Yes	Yes
	San Joaquin kit fox	No	No
	Striped skunk	No	No
Los Angeles	Bobcat	No	No
	Bobcat	No	No
Napa	Eastern fox squirrel	No	No
Riverside	Desert kit fox	No	No
Sacramento	Gray fox	No	No
	Striped skunk	Pending	Pending
San Benito	Bobcat	Yes	Undetermined
San Luis Obispo	Long-tailed weasel	No	No
Santa Clara	Eastern fox squirrel	Yes	Yes
	Opossum	No	No
	Opossum	No	No
Santa Cruz	Gray fox	Yes	Yes
	Mountain lion	Yes	Undetermined
Sonoma	Raccoon	Yes	Yes
	Striped skunk	Pending	Pending
	Striped Skunk	Pending	Pending
Total		**6**	**4**

ADDITIONAL SURVEILLANCE

Anticoagulant Rodenticide Exposure in American Black Bears from Humboldt County

Paired liver and muscle samples from 14 American black bears taken on depredation permits in Humboldt County were submitted to the WHL for anticoagulant rodenticide testing (brodifacoum, bromadiolone, chlorophacinone, coumachlor, difethialone, diphacinone, warfarin, and difenacoum). The age class and the sex of the bear samples submitted were not specified.

Anticoagulant rodenticides were not detected in any of the submitted tissue samples.

Anticoagulant Rodenticide Exposure in Wild Pigs from North Central Coastal Counties

Paired liver and muscle samples from 36 wild pigs taken on depredation permits were submitted to the WHL for anticoagulant rodenticide testing (brodifacoum, bromadiolone, chlorophacinone, coumachlor, difethialone, diphacinone, warfarin, and difenacoum).

Wild pig samples came from six California counties: Contra Costa (n = 4), Lake (n = 7), Napa (n = 4), San Luis Obispo (n = 8), Santa Clara (n = 8), and Solano (n = 5). All sexes and juvenile and adult classes were represented in the submitted samples.

Of the wild pig samples that were submitted for toxicology testing, 8% (3/36) had exposure to a single anticoagulant rodenticide: 1) an adult female from Contra Costa County had a trace detection of chlorophacinone, 2) an adult male from San Luis Obispo County had a trace detection of diphacinone, and 3) an adult female from San Luis Obispo Cunty had a trace detection of diphacinone. Anticoagulant rodenticides were only detected in liver samples; there were no detections in the muscle samples taken from the same individual.

Environmental Samples

Seven samples collected from illegal marijuana grow sites were tested for toxic compounds. Carbofuran was detected in three samples, one sample did not have any detectable level of toxic analyte, and three samples are pending results at the time of this report.

Seven samples collected by CDFW law enforcement at trespass or illegal marijuana cultivation sites were submitted for toxicology testing. Six of the samples were positive for carbofuran (Table 13).

Table 13. Toxicology results for seven samples collected from various marijuana clean-up sites in California submitted to the Wildlife Health Laboratory in 2020.

County	Submitted Sample	Toxicology Results
Tehama	Water	No detection
Tehama	Water	Carbofuran
Stanislaus	Pink liquid	Carbofuran
Stanislaus	Pink liquid	Carbofuran
Shasta	Pink liquid	Carbofuran
Lassen	Pink liquid	Carbofuran
Not specified	Pink liquid	Carbofuran