# ABSTRACTS

**30th VERTEBRATE PEST CONFERENCE**

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**Reno, Nevada**


*Conference Chair:*
**Roger Baldwin**

*Program Chair:*
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# ABSTRACTS FOR SESSIONS AND SYMPOSIA

## Tuesday, March 8 (AM) KEYNOTE ADDRESS AND PLENARY SESSION

9:20 **Challenges and lessons learned from European rodent management**

*Jens Jacob*
Julius Kühn-Institute, Federal Research Centre for Cultivated Plants, Münster, Germany.

The majority of mammalian species are rodents, which provide important ecosystems services. However, in Europe, about 10% of rodent species can cause considerable damage in agriculture, forestry and to infrastructure, pose serious problems for hygiene and conservation, and transmit a multitude of zoonotic pathogens to humans and livestock. The risk associated with commensal Norway rats (*Rattus norvegicus*) and house mice (*Mus musculus*) (hygiene, infrastructure, pathogens) is mainly chronic and personal tolerance for the presence of these species is minimal. The risk related to particular vole species such as common voles (*Microtus arvalis*) and bank voles (*Myodes glareolus*) for agriculture, forestry and disease transmission is mainly restricted to population outbreaks.

Not surprisingly, management strategies differ between commensal rodents and forest/field rodents but the method of choice for all of them was the use of rodenticides in the past and in Europe, this is also the case presently. This is likely to change in the future as growing concern about environmental risk, public opinion and political decision makers cause a shift to methods that meet a wish list that includes several requirements such as non-toxic, non-lethal and in favor of animal welfare. This is a tremendous challenge. Regulating the use of rodenticides down as it has happened in Europe for at least the last 15 years is easy. For instance, in the EU, plant protection is now limited to the use of a couple of phosphine generating compounds. The search for alternatives is not easy but the need to reduce rodent related problems is a reality and these problems may well increase given a rising world population, effects of climate change and growing human-wildlife contacts.

Non-chemical alternatives effective in regulating pest rodent populations down such as reduced vegetation height or intensive tillage are often in conflict with efforts to increase biodiversity and to decrease erosion. Other management methods such as trapping may not be cost effective at large scale and there may be non-target issues or their efficacy in reducing damage/increasing yield is unknown (biocontrol). Current concepts suggest that rodent management in the future is unlikely to rely on rodenticides alone but to combine several tools, use the approach of ecologically-based rodent management and predictive models to focus action on when and where necessary. This will require sound research to find optimal combinations of existing, optimized and new methods (e.g., use of rodent fertility control, rodenticidal compounds with improved environmental profile, plant secondary compounds) to ensure healthy food, healthy people and healthy environment.

10:45 **Development of a New Immunocontraceptive for Use in Feral Horses**

*Jason Bruemmer, Douglas C. Eckery, Cary Mundell, Megan Eisenfelder*
USDA APHIS WS National Wildlife Research Center, CO.

Feral and free-roaming horse populations continue to grow as they overgraze and devastate rangelands, riparian areas, and local wildlife, often at their own peril. Lethal control, while highly effective, is not an option as these animals have gained heritage status with the public and are protected by the Wild Horse and Burro Act. Current management practices are focused on capture and removal which come at a significant cost both in the process and long-term care that follows. Fertility control is regarded a promising management option. There are currently two immunocontraceptive products available for use in horses, but both require at least an initial dose followed by a booster months to years later, making application very difficult and highly impractical. Our goal is to develop a single dose long lasting contraceptive. Because all females are born with a finite population of oocytes, these cells have been chosen as the target. Two oocyte-specific growth factors have been identified, GDF-9 and BMP-15. A GDF-9 antigen was made representing amino acids 20-33 of the mature protein, while the BMP-15 antigen was produced representing the first 24 amino acids in that mature sequence. A vaccine was formulated using a mild adjuvant and mares were treated with the vaccine multiple times over several months. All treated mares developed antibodies and demonstrated infertility for an entire year. Interestingly, 88% of the mares remained infertile for the following year even though they had not been

re-vaccinated and, in fact, had no antibody titers remaining. Current research efforts are underway to identify the best adjuvant to elicit an appropriately long immune response.

11:10 **Twenty Years of Big-Brown Bat Rabies Virus Cross Species Transmission in Flagstaff, Arizona, 2001-2021**

*David L. Bergman[1], Sabrina Kelley[2], Lolita I. Van Pelt[1], Tad Theimer[3], John Marciniak[4], Scott Brunt[5], April Davis[5], Kathryn Fitzpatrick[6], Lillian Orciari[7], Lias Hastings[1], Amy Gilbert[8], Charles E. Rupprecht[9], Richard Chipman[10]*

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Flagstaff, Arizona, has experienced big brown bat (*Eptesicus fuscus*) rabies virus (RABV) variant cross species transmission (CST) between 2001 and 2021 and have primarily involved striped skunks (Mephitis mephitis) and gray foxes (*Urocyon cinereoargenteus*). Repeated CST infections led to concerns over possible long-term adaptations and RABV host shifts into novel species and the subsequent need for management intervention. Collaborative responses were led jointly by Coconino County and the US Department of Agriculture involving enhanced rabies surveillance and targeted wildlife rabies management to protect human and animal health. During 2001, an intensive trap-vaccinate-release (TVR) campaign was implemented to control the epizootic. A new RABV epizootic began in 2004 and was addressed using a TVR campaign in cooperation with the nuisance wildlife control operators (NWCO) and an experimental use of Raboral VRG targeting skunks. In 2008, a confirmed rabid gray fox was documented with a big brown bat RABV variant. Because of the CST in mesocarnivore species, primarily gray foxes, a large-scale oral rabies vaccine baiting program, targeting gray foxes, was conducted over three summers. Additionally, a more localized TVR program, targeting striped skunks, began in July 2009, led by WS in close collaboration with Flagstaff-based NWCOs. To better understand these localized outbreaks, a variety of applied research was led by Northern Arizona State University, focused on the ecology of striped skunk and bats. On August 5, 2021, a new CST event was confirmed in a striped skunk. As of December 31, 2021, 16 striped skunks were determined to have an identical RABV variant of big-brown bat rabies. The current collaborative effort includes a USDA led TVR and TVR with NWCO, and enhanced rabies surveillance in addition to a variety of laboratory research projects to better understand the CST dynamics of RABV in Arizona, with broader implications for the Americas.

11:35 **Anticoagulant Rodenticide Exposure in Red Kites (*Milvus milvus*): Regulatory Changes and Analytical Progress Change the Picture!**

*Philippe Berny, Valentin Bondoux, Danièle Vey*
Vetagro Sup - Toxicology, Marcy, France.

Anticoagulant exposure or poisoning has become a major issue in wildlife. It is described worldwide, with the large use of anticoagulant rodenticides (AR) to control population of field or commensal rodents. In the recent years, analytical techniques have relied mostly on LC-MSMS to detect and quantify AR down to the ?g/kg concentration in tissues and organs. We developed QuEChERS to analyze biological specimens for most AR marketed in Europe and a rapid LC-MSMS multiresidue method to analyze liver, plasma, and blood samples. One of our objectives was to compare blood and plasma as potential samples from wildlife sinceit is generally easier to collect blood samples from dead animals, but only plasma analysis has been described. The purpose of this presentation is to discuss some of the issues associated with analytical investigation of AR poisoning in wildlife, including analytical issues (sensitivity, specificity, linear or quadratic model to quantitate AR), trouble-shooting (as we encountered) and solutions (some of which are currently developed under a COST Action by the EU). Recent studies have shown the importance of isomers in the toxicity and persistence of AR in organs. It is possible to detect and quantify those isomers in many situations, but the need for a specific isomer quantification is debatable in wildlife poisoning. Our results indicate that AR are detected in whole blood.

There is a good correlation between plasma and blood concentrations, but plasma concentrations are always lower (70-80%), suggesting that AR are present in red blood cells. This is important since plasma concentrations decrease rapidly after exposure, and most exposed animals appear as false negative but AR may be present for a longer period of time in red blood cells. This would have pharmacokinetic consequences and provide a simple way of confirming exposure to AR event when plasma concentrations are undetectable.

## Tuesday, March 8 (PM)-RODENT MANAGEMENT

1:25 **Influence of California Ground Squirrels on Forage Availability for Ranching Operations**

*Devii Rao[1], Theresa A. Becchetti[2], Josh S. Davy[3], Royce E. Larsen[4], Fadzayi E. Mashiri[5], Ryan Meinerz[6], Rebecca K. Ozeran[7], Roger A. Baldwin[6]*

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California ground squirrels (*Otospermophilus* spp.) cause more economic damage to California rangelands than any other rodent. Damage comes in many forms, although forage loss is likely the greatest concern. These losses are believed to be significant for ranchers, particularly given the economically marginal environment that they exist in, yet our understanding of these economic losses is limited. Furthermore, current public opinion is often not supportive toward ground squirrel control on many public grazing lands. Data on the impact that ground squirrels have to these valuable rangelands may be needed to justify management actions in the future. Therefore, we tested the amount of standing crop removed by ground squirrels across 16 sites at four different density categories of ground squirrels per site in central California rangelands during 2019 and 2020. We also included precipitation and livestock grazing intensity to help account for their potential effect on forage production. We found that ground squirrel abundance negatively affected standing crop, with available forage reduced by 27.2 kg ha-1 for each ground squirrel. Likewise, precipitation influenced forage production, with each cm of precipitation yielding a 16.6 kg ha-1 increase in available forage. We did not observe any effect of livestock grazing intensity, an interaction between livestock grazing intensity and ground squirrel abundance, nor an interaction between precipitation and ground squirrel abundance on residual standing crop. Collectively, this information will be useful to ranchers to help determine when control efforts may be needed for California ground squirrels given relative abundance of ground squirrels on their rangeland properties.

1:50 **Evaluating the Use of Barn Owl Nest Boxes for Rodent Pest Control in Winegrape Vineyards in Napa Valley**

*Ashley Hansen, Matthew D. Johnson*
Humboldt State University, Arcata, CA.

Attracting natural enemies to farms to reduce pests has long been a part of integrated pest management for insects, but knowledge of the impact of raptors on rodent and other vertebrate pests is comparatively sparse. Using wooden nest boxes to attract rodent-eating barn owls (*Tyto alba* and *Tyto furcata*) to farms has been practiced in many regions for decades, but to date there have only been a handful of studies actually comparing rodent numbers in the presence and absence of barn owl nest boxes, and none done within the Western United States. In this study, we surveyed rodent prey on winegrape vineyards in Napa California with and without occupied barn owl nest boxes. We collected data before the breeding season, when hunting pressure should be light, and again when adults were hunting actively to feed their chicks. We used the open hole method to quantify an index of gopher activity, and Sherman live traps to estimate minimum number alive of other rodents. We found that gopher activity declined from before to peak hunting pressure on the vineyard with barn owl nest boxes, whereas it remained relatively stable on the vineyard without nest boxes. Live trapping revealed that the abundance of mice declined from before to peak hunting pressure, but this decline was not significantly affected by the presence of nest boxes Results were inconclusive for voles

because they not well-sampled by our live trapping method, even though analysis of owl pellets confirmed they are an important source of prey for barn owls. Future work should replicate this study after adding nest boxes to the vineyard that lacks them and employ another method to assess vole abundance or activity.

2:15 **Improving Efficiency of Prairie Dog Surveys Using a Small Copter Drone**
*Aaron Shiels, Justin Fischer, Danika Spock, Meagan Allira*
USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO.

Prairie dogs (*Cynomys ludovicianus*) and other ground squirrels often require occasional survey because populations can change due to natural fluctuations, plague outbreaks, or human-induced control. We evaluated the use of small copter drones at four prairie dog colonies near Boulder, Colorado, to determine if this methodology improves efficiency over ground-based survey methods. We counted prairie dogs and burrows using two types of drones (DGI and Autel) at altitudes 100', 150', and 400' (burrows only). We recorded video and merged still images into a mosaic prior to having USDA staff analyze this imagery. We then compared the drone imagery counts to those of our simultaneous ground-based counts of prairie dogs. In most cases, the 100' altitude mosaics produced using DGI drone were most accurate (closest to true, ground-based counts) for burrow abundance and generally so for prairie dog abundances. 150' video was more accurate than 100' video. Both staff members required about the same amount of time to count/analyze imagery; videos could be evaluated slightly faster than mosaics (average of 3.8 hours vs. 5.5 hours per imagery), and burrow counts (of mosaics) generally took 2-3 times longer to analyze than did prairie dog counts. The labor requirement of using drones for burrow and prairie dog counts is far more time consuming (3-4 times longer per hectare) than having field staff conduct the traditional on-the-ground counts. Until technology improves and target colonies are very large (>2 km2) or inaccessible, drone surveys are unlikely to be a more efficient technique than ground-based surveys for evaluating prairie dog abundances.

2:40 **Abert's Squirrel Management in Support of Endangered Mount Graham Red Squirrel Recovery in Arizona**
*Aaron Morehead[1], Christopher D. Carrillo[1], Holly Hicks[2], Wade Sanders[1], David L. Bergman[1]*
[1]USDA/APHIS/Wildlife Services, Phoenix, AZ.
[2]Arizona Game and Fish Department, Phoenix, AZ.

Recovery of the endangered Mount Graham red squirrel (MGRS) (*Tamiasciurus fremonti grahamensis*) will likely be long and challenging. Its limited habitat, isolation to Pinaleño Mountain range, and demographic characteristics restrict its ability to rebound quickly from threats that impact both the squirrel and its habitat. Currently, threats to the MGRS include habitat degradation and loss through high-severity wildfire, fire suppression activities, insect outbreaks, climate change, and human development, as well as competition with Abert's squirrels (*Sciurus aberti*) and predation. The most recent wildfire in 2017 impacted over 48,000 acres in already reduced habitat. A critical first step is to protect and manage the remaining population of the MGRS and its habitat. Management includes, but is not limited to, maintaining and improving the spruce-fir and mixed conifer biomes while balancing the need to reduce risk of catastrophic wildfire with the needs of the squirrel. The US Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services is conducting an Abert's Squirrel Removal Project at the request of the Arizona Game and Fish Department and the US Fish and Wildlife Service in collaboration with a team of Mount Graham red squirrel experts and managers to reduce the number of Abert's squirrels in historical MGRS habitat throughout the Pinaleño Mountains to assist in meeting the needs of the US Fish and Wildlife Service 2011 MGRS draft recovery plan. Abert's squirrel removals are conducted on a monthly basis to minimize competition with MGRS.

3:20 **Continuing Field Efficacy of Norbormide Against Both *Rattus rattus* (Ship Rats) and *Rattus norvegicus* (Norway Rats)**

*Lee E. Shapiro[1], Kirtana Kumar[1], Charles T. Eason[2], Duncan MacMorran[3], David Rennison[3], Margaret Brimble[3]*
[1]Boffa Miskell, Lincoln, New Zealand.
[2]Lincoln University, Lincoln, New Zealand.
[3]Connovation Ltd, Aukland, New Zealand.
[4]University of Auckland, New Zealand.

Norbormide is a uniquely selective rat toxicant with rats being 100 to 150-fold more sensitive to norbormide toxicity than most other mammals and birds. Previously we reported that we had overcome taste aversion and established the efficacy of norbormide-containing baits targeting rat infestations on poultry farms and achieved 100% and 96% reductions of wild Norway rat (Rattus Norvegicus) populations. In 2021 larger scale field trials were undertaken on Banks Peninsula, near Christchurch, New Zealand targeting ship rats (Rattus rattus), using the same new 1% norbormide paste baits. The trial sites of approx. 27 hectares consisted of isolated native bush and scrub patches within farmland, with ship rats present at both. An untreated site was also selected and consisted of approx. 65 hectares of similar habitat. Rat monitoring undertaken prior to toxic baiting recorded moderate levels of rat activity at all trial sites. Following toxic baiting, with 1% norbormide bait, post-treatment monitoring was undertaken. Independent assessors recorded a 100% reduction in rat abundance at both test sites and no reduction at the untreated control site. This reduction in the ship rat population at both sites was the first reported field trial of norbormide targeting ship rats. Plans are progressing to complete product development and registration.

3:45 **An Assessment of Quantitative Indexing Tools and Movement Patterns in Invasive Roof Rats in Citrus Orchards**

*Roger A. Baldwin, Ryan Meinerz, Justine A. Smith*
Department of Wildlife, Fish, and Conservation Biology-University of California, Davis, CA.

Roof rats cause extensive damage in a number of tree crops including citrus. Roof rat populations seem to be expanding and growing throughout many agricultural regions in CA, yet management options for limiting this damage have been largely unsuccessful. The development of an integrated pest management (IPM) program could greatly reduce this damage, but such a program is challenging to develop without at least a basic understanding of the general biology and ecology of the pest species within the target system. As such, we conducted a study using new cellular-tracking technology to gain a better understanding of roof rat movement patterns to better target management programs. We also tested the utility of tracking tunnels and remote-triggered cameras to serve as quantitative indexing tools to track changes in population size following the implementation of various management tools. We found that roof rats exclusively used orchard habitats, and that they were active almost exclusively at night. The roof rats at our study sites also moved relatively large distances within orchards, suggesting that traps or bait stations could be spread out to reduce management costs. For indexing tools, we found that both tracking tunnels and remote-triggered cameras (both binary and continuous response metrics) were correlated to roof rat abundance irrespective of their location on the ground or in the trees. We also noted a difference in the relationship between index values and roof rat abundance for lemon and orange orchards, indicating the importance of considering orchard type when interpreting models. Collectively, this information will serve as the foundation for subsequent studies designed to assess the utility of potential control options for reducing roof rat numbers in citrus, eventually leading to the development of an IPM approach for managing roof rats in this valuable crop.

4:10 **Managing Roof Rats in Citrus Orchards: Failures and Potential Successes**

*Ryan Meinerz[1], Roger A. Baldwin[1], Aaron B. Shiels[2]*
[1]Department of Wildlife, Fish, and Conservation Biology-University of California, Davis, CA.
[2]USDA/APHIS/WS-National Wildlife Research Center, Fort Collins, CO.

Invasive roof rats (Rattus rattus) are one of the most damaging vertebrate species to agriculture globally. In citrus crops, they cause a variety of types of damage including consumption of fruit and girdling of branches. Managing roof rats in citrus is challenging given the abundance of food and cover provided by the trees year-round. Anticoagulant rodenticide applications applied via bait stations are sometimes used to manage roof rats in orchards, but have not been tested in an evergreen crop like citrus. Repeating Goodnature A24 traps

are increasingly used to manage roof rats for conservation purposes, but have not been tested in agricultural orchards. As such, we set up a study to test the efficacy of: 1) 0.005% diphacinone-treated oats applied via elevated bait stations and 2) A24 traps. This study was conducted across four citrus orchards in the southern San Joaquin Valley, California, to better identify how to implement these tools to manage invasive roof rats in this important crop. Although neither trapping nor rodenticide baiting yielded the desired reduction in roof rats across all sites, we did identify strategies that hold promise for future testing. For rodenticides, reducing the spacing between bait stations may increase efficacy by increasing encounter rates by rats. For trapping, the use of a platform under the A24 traps appeared to increase its effectiveness by allowing easier access to the trap trigger. Furthermore, reducing spacing between traps or rotating trap locations may also yield better results. Ultimately, a management plan that combines trapping and rodenticide baiting, while periodically rotating trap and bait station locations, may prove more efficacious than our initial study design, and should be investigated further.

4:35 **New Baits to Control Blacklegged Ticks Feeding on Two Host Species: Lyme Disease Implications**
*David Poche[1], Richard Poche[1], Donald Wagner[2]*
[1]Genesis Labs, Inc., Wellington, CO.
[2]Pennsylvania State University, University Park, PA.

Lyme disease is the leading vector-borne disease transmissible to humans in the United States. Control strategies directly targeting pathogen hosts (white-footed mice) and reproductive hosts (white-tailed deer) could markedly reduce pesticide application rates, reduce tick survivorship and reproduction, and subsequently reduce risk of human Borrelia burgdorferi infection. We developed a low dose fipronil bait, for oral consumption by small rodents such as white-footed mice, to control immature blood-feeding blacklegged ticks. Mice were presented fipronil bait under simulated field conditions. Mice were then manually infested with tick larvae. The results indicated that larvae blood-feeding on treated mice could be significantly controlled when mice were infested up to Day-15 post-exposure (24-hour bait exposure), and up to Day-35 post-exposure (168-hour bait exposure). A low dose fipronil feed, to control adult blacklegged ticks blood-feeding on white-tailed deer, is under development. Captive deer (Pennsylvania State University) were presented fipronil feed for 48-hours in a range finding study. Ticks were inserted into feeding capsules attached to each deer at Day-1 post-exposure. Results suggested that ticks blood-feeding on deer could be significantly controlled at all concentrations evaluated. Upcoming research will more explicitly evaluate fipronil efficacy against adult ticks and investigate potential residues in various deer tissues. Study results provide an early indication of the potential effectiveness of oral fipronil against ticks feeding on multiple host species. Field trials are needed to optimize the application scheme for delivery of oral acaricides to rodents and deer to maximize the suppression of infected ticks posing risk to humans.

## Tuesday, March 8 (PM)- WILDLIFE DISEASES/ZOONOSES

1:25 **Sarcoptic Mange in Urban Kit Foxes: Potential for Cross-Species Transmission**
*Erica C. Kelly[1], Brian L. Cypher[1], Tory L. Westall[1], Nicole A. Deatherage[1], Jaime L. Rudd[2], Deana L. Clifford[2]*
[1]California State University, Stanislaus, CA.
[2]Calfifornia Department of Fish and Wildlife, Rancho Cordova, CA.

A robust population of endangered San Joaquin kit foxes (*Vulpes macrotis mutica*) occurs in the city of Bakersfield, CA. In March 2013, sarcoptic mange was detected in this population and the mite quickly spread. In January 2019, mange also appeared in a smaller kit fox population in the neighboring town of Taft, CA. To date there have been 430 confirmed cases and 98 confirmed deaths. An additional 118 individuals are considered deceased because there is no indication that kit foxes recover without medical intervention. These numbers are also presumed underestimations of the actual number of kit foxes that have contracted and died from mange. In addition to mange response, the Endangered Species Recovery Program (ESRP) has conducted a yearly citywide camera survey in Bakersfield since 2015 and Taft since 2019 to assess the occurrence of mange among kit foxes and the spatial pattern of spread. Based on the Bakersfield survey, the urban kit fox population has declined by 67% since 2015. This annual camera survey also provides useful information on co-occurring species that could contract or transmit mange. Of the total number of cameras that have detected kit foxes with mange, 91% of those also detected at least one secondary species including raccoons (*Procyon*

*lotor*), opossums (*Didelphis virginiana*), striped skunks (*Mephitis mephitis*), California ground squirrels (*Otospermophilus beecheyi*), and domestic cats and dogs (*Felis catus* and *Canis familiaris*). The annual camera surveys have also detected coyotes (*C. latrans*), red foxes (*V. vulpes*), gray foxes (*Urocyon cinereoargenteus*), and opossums with active mange infestations. Transmission routes for all of these species remain uncertain and the potential for transmitting mites to new areas or new individuals of multiple species is possible. Overall, mange presents a risk to multiple species in the urban environment, including domestics, for as long as it continues to circulate.

1:50 **Surveillance for Snake Fungal Disease in California's Free-Ranging Snakes**
*Raquel Elander*
University of California, Davis, CA.

Snake fungal disease (SFD, ophidiomycosis), caused by the fungus *Ophidiomyces ophiodiicola* (Oo), has emerged as a major challenge for snake conservation. The fungus primarily causes skin lesions ranging from minor scale abnormalities to severe swelling, ulceration, and disfiguration, but it can also lead to more severe outcomes such as loss of tissue or bone and death. Transmission likely occurs through contact with the soil and contact with other infected individuals. In 2019, the California Department of Fish and Wildlife (CDFW) confirmed the state's first two cases of SFD and Oo in a California kingsnake *(Lampropeltis californiae*) received by a wildlife rehabilitation center and an invasive Florida watersnake (*Nerodia fasciata pictiventris*) collected during targeted removal efforts. In response to the emergence of SFD in California, the CDFW and its collaborators, including the public, wildlife and snake researchers, wildlife rehabilitators, and reptile enthusiasts, are actively conducting surveillance throughout the state to determine the prevalence and geographic extent of clinical SFD and the causative fungus (Oo), in multiple species of snakes. Methods for completing this task include active field surveying and sampling for free-ranging snakes within our study areas in California. Sampling for determining SFD and Oo presence will be done by collecting epidermal skin swabs and doing a physical wellness exam with associated morphological and demographic information from all snakes; additionally, we will collect snake carcasses, and investigate reports of sick snakes submitted to the CDFW's Wildlife Health Lab portal. Our goal is to provide education on the value of snakes in our ecosystems, raise awareness on how human practices may impact snake communities, and obtain an urgently needed assessment of the health of California's free-ranging snakes. These efforts will provide valuable information that will support the management and conservation of snakes.

2:15 **Update of Wildlife Diseases in Nevada**
*Nate LaHue*
Nevada Department of Wildlife, Reno, NV.

Wildlife in Nevada are under threat from a variety of wildlife diseases from RHDV2 to bighorn pneumonia, to botulism. Other diseases are of particular importance to human health. Others are not present in Nevada wildlife but represent emerging threats to Nevada's wildlife should they be introduced. Those working with wildlife in Nevada have an important role both in the prevention of movement of disease between wildlife and then introduction of new diseases to Nevada wildlife populations. This presentation will cover current wildlife disease issues in Nevada such as RHDV2, bighorn sheep pneumonia, botulism, rabies and others as well as emerging threats such as WNS, SARS-CoV-2, and others as well as some of the aspects of Nevada that make some species particularly vulnerable.

2:40 **California's Chronic Wasting Disease Surveillance Program**
*Alex Heeren, Brandon Munk, Linell Hansen, Robert Karam*
California Department of Fish and Wildlife, Rancho Cordova, CA.

Chronic Wasting Disease (CWD) poses a severe challenge to managing and conserving deer and elk populations. Since CWD has not yet been detected in California, the state is engaged in a surveillance program to monitor the health of California's mule deer (*Odocoileus hemionus*) herds. California's surveillance program uses a three-pronged approach. First, the California Department of Fish and Wildlife (CDFW) operates a set of hunter check stations where hunters can submit harvested deer for testing. Second, CDFW is collaborating with other researchers to develop a risk assessment tool in order to identify and prioritize areas within the state that are at high risk for CWD introduction. Finally, CDFW is engaged in multiple communication and outreach initiatives to spread the word of the risks CWD poses and promote best practices for handling and

processing harvested deer. This presentation will provide an introduction to California's CWD surveillance program and discuss the future directions for monitoring the health of California's deer population.

3:20 **Investigating Protozoal Parasites as Causes of Neurologic Disease in American Black Bears (*Ursus americanus*) that Contribute to Human-Wildlife Conflict**

*Devinn Sinnott[1], Karen Shapiro[1], Brandon Munk[2], Nate LaHue[3], Leslie Woods[4], Kate Watson[4], Omar Gonzales-Viera[4]*

[1]University of California, Davis, CA.

[2]California Department of Fish and Wildlife, Rancho Cordova, CA.

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[4]California Animal Health and Food Safety Laboratory, San Bernadino, CA.

A unique neurologic disease affecting juvenile American black bears (Ursus americanus) was first observed in 2014 near Lake Tahoe and has since been reported in eight California counties and two Nevada counties. Affected bears exhibit a range of neurologic symptoms including tremors, seizures, and over-habituated, dog-like behavior. These neurologic and behavioral changes put affected bears at increased risk of human-wildlife conflict and public safety situations that require intervention by state wildlife departments. Affected bears have varying degrees of inflammation in the brain (encephalitis), but the cause of this encephalitis is currently unknown. Several viruses have been identified in the brains of affected bears but a direct correlation between viral infection and encephalitis has not been proven. The goal of this study was to investigate the possible role of protozoal parasites in this encephalitis of unknown origin. Brain tissue from neurologic bears (n=20) and unaffected bears (n=14) from California and Nevada was screened via PCR targeting two genes (ITS1 and 18S). Protozoal parasite DNA was detected in 50% of neurologic bears (10/20) and 21.4% of unaffected bears (3/14). Parasites detected in neurologic bears included multiple Sarcocystis species (7/20), Toxoplasma gondii (1/20), and an uncharacterized Cystoisospora-like species (2/20). Parasites detected in unaffected bears included an uncharacterized Sarcocystis species (1/14) and an uncharacterized Cystoisospora-like species (2/14). Sarcocystis species and T. gondii are known causes of encephalitis in bears as well as other wildlife and domestic animals. These results suggest that protozoal parasites, particularly Sarcocystis species, may contribute to encephalitis in juvenile black bears, creating a public safety hazard at the human-wildlife interface.

3:45 **Detection of *Toxoplasma gondii* in Feral Cats in Central Coastal California**

*Sophie Zhu[1], Lauren Camp[1], Anika Patel[1], Elizabeth VanWormer[2], Karen Shapiro[1]*

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*Toxoplasma gondii* is a zoonotic parasite that can cause severe morbidity and mortality in warm-blooded animals, including marine mammals like the southern sea otter (*Enhydra lutris nereis*). Felids, including free-ranging domestic cats, can shed environmentally resistant *T. gondii* oocysts in their feces. Contamination of nearshore waters can occur following surface runoff that can mobilize oocysts from contaminated soil to water bodies. Certain genotypes of *T. gondii* are associated with a higher likelihood of fatal infection in sea otters, and some of these genotypes have previously been isolated from felid tissues in the greater Monterey Bay region. There is limited knowledge on the frequency of oocyst shedding and genotypes of oocysts shed by free-ranging cats in their feces despite their large population sizes and ability to contribute to environmental oocyst contamination. Utilizing a longitudinal field study at four free-ranging cat colonies in central coastal California, we are evaluating the seasonal variation of *T. gondii* oocyst prevalence in feces using microscopy and molecular methods. Positive samples are being characterized to determine parasite genotype. Free-ranging feral cats can contribute to biological pollution of the marine environment, and proper management of these animals could play an important role in reducing environmental contamination of oocysts and subsequent *T. gondii* infection in endangered marine mammals.

4:10 **Disease Surveillance of Invasive Nutria (*Myocastor coypus*) Inhabiting Wetlands in California's Central Valley**

*Jane Riner[1], Leslie M. Woods[2]*
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[2]California Animal Health and Food Safety Laboratory, San Bernadino, CA.

Nutria (*Myocastor coypus*) are semi-aquatic rodents native to South America that have been introduced into many countries outside their native range where their prolific breeding and feeding habits have resulted in widespread, adverse impacts on wetland ecosystems. Nutria can also host zoonotic pathogens and pose infectious threats to other species. The 2017 re-emergence of nutria in the California Central Valley, nearly 50 years post eradication, necessitates further investigation into the impacts of this species. In this study, we investigate whether nutria in California serve as hosts for infectious agents that present spillover risk to susceptible host populations including native wildlife, domestic animals, and humans. We used histopathology, PCR, immunoassays, and morphologic identification of ectoparasites to evaluate the presence of pathogens or arthropod vectors in a subset of nutria dispatched during the first year of a statewide eradication effort. Common histopathologic findings included lymphocytic and granulocytic interstitial pneumonia and hepatitis with intralesional cestodes. One nutria fecal sample was positive for Giardia intestinalis assemblage B by PCR amplification and DNA sequencing. Three nutria had positive serum antibody titers against *Leptospira interrogans* serovars Canicola or Pomona. We did not detect pathogenic *Leptospira spp*. by RT-PCR. We did not detect *Salmonella spp*., *Bartonella spp*., *Borrelia burgdorferi sensu lato*, *Francisella tularensis*, *Cryptosporidium parvum*, *Toxoplasma gondii*, or Sin Nombre orthohantavirus by PCR or immunoassays. All ticks were identified as *Dermacentor variabilis*. Fleas were identified as *Pulex sp*. and *Orchopeas sp*. Although the prevalence of animals PCR or serology positive to pathogens in this study was relatively low, this surveillance effort highlights the potential for nutria in California to serve as hosts for waterborne pathogens that can result in disease in humans and other animals. Continued surveillance of nutria and their associated pathogens will inform disease preventive measures and mitigation of potential nutria impacts on native species.

## Wednesday, March 9 (AM) MANAGEMENT OF HOOVED ANIMALS

8:15 **What is a Wild Horse?**

*Tolani Francisco[1], France Maisonneuve[2]*
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Wild is a term so often utilized to refer to any free-roaming animal on the landscape. When addressing horses, there is a very specific use of the term wild. The Wild Free-Roaming Horses and Burros Act of 1971 (Public Law 92-195) aka The Act states "wild free-roaming horses and burros" means all unbranded and unclaimed horses and burros on public lands of the United States but does not include any horse or burro introduced onto the National Forest System on or after December 15, 1971, by accident, negligence, or wilful disregard of private ownership (36 CFR 222.60). It also states "range" means the amount of land necessary to sustain an existing herd or herds of wild free-roaming horses and burros, which does not exceed their known territorial limits and which is devoted principally but not necessarily exclusively to their welfare in keeping with the multiple-use management concept for the public lands. Both the Secretary of Interior and Agriculture are responsible for administration of The Act. The Bureau of Land Management (BLM) and the Forest Service (FS) have designated land; either a Herd Management Area (HMA) which is BLM and Wild Horse and/or Burro Territories (WHBT) for FS. In some instances, there are Joint Management Areas (JMA) in which both the BLM and the FS have overlying areas and jointly manage the land and animals. It is only on these lands where the animals identified in 1971 and their progeny, when the areas were established have federal protection as outlined in The Act and are legally wild horses or burros. The Act also specifically identifies wildlife is part of the multiple use relationship and the state wildlife agency where the BLM and/or FS have designated lands and wild horse herds. Public land does not include Tribally owned land, which is sovereign and either held in Trust or is Deeded to that specific tribe. In cases where there is no HMA, JMA or WHBT, but there are free-roaming horses or burros on public lands (BLM or FS), these animals are either feral or trespass. The difference is often difficult to distinguish, generally it is an animal or its progeny which have signs of domestication. There is no specific genetic test (blood, fecal, hair) that can identify a horse as wild, feral or trespass. The genetic tests

establish the genetic material common in known lineages of horses and all have multiple genetic markers and make-up

8:40 **Opportunities for Local Partnerships in Managing Free-Roaming Equids**
*Laura K. Snell*
University of California Cooperative Extension, Alturas, CA.

In Modoc County, located in northeastern California there is a high elevation sage-steppe rangeland ecosystem heavily populated by free roaming equids and managed primarily by the United States Forest Service (USFS) known as the Devil's Garden. Free roaming equids have significantly exceeded (roughly 2000 horses) appropriate management levels (206-402 horses) in the last decade and expanded their range outside of the designated territory (258,000 acres) and on to private and tribal lands (over 450,000 acres) degrading rangeland and threatening endangered species. Helicopter gathers in recent years have removed over 2000 equids from the Devil's Garden. Due to the extensive collaboration between the USFS, Modoc National Forest, and local partners, many of these equids have found new homes. An early collaborative group developed unique strategies for placement of old (historically characterized as unadoptable) and young horses. Modoc County utilized the government to government communication process to participate in management decisions and worked to change federal law to provide USFS equal opportunity to placement programs. A robust social media campaign ran by local volunteers has created a brand for the Devil's Garden equids and educated the public on the declining range condition and equid health. Volunteers also matched potential adopters and buyers with transportation options for cross country transportation and some funding for transportation of large groups of equids was provided. Finally, the Devil's Garden Colt Challenge has placed nearly 100 horses with 4-H and FFA youth over the last three years across California. Current status of the management strategies will be shared and future plans.

9:05 **Fertility Control Options for Free-Ranging Horse Populations Highlighting Spayvac®-Equid**
*Ursula Bechert*
University of Pennsylvania, Philadelphia, PA.

As wildlife populations become increasingly confined to smaller ranges due to the expanding human footprint, they can become locally overabundant, resulting in conflicts and negative effects on other species. Population management methods offer band-aid solutions to this problem. Free-ranging horses are particularly challenging to manage, because populations can grow at 15-20% annually, their habitats are diverse, stakeholders have different objectives, and people hold strong opinions about how horses should be managed (if at all). The Bureau of Land Management currently manages free-roaming equids on 177 herd management areas in the U.S. mainly by removing horses, which are then either adopted by private individuals or sent to long-term holding facilities. Various fertility-control methods may be applied to horses remaining on the range. Implementation challenges are site-specific, based on terrain and other variables. Using one or more fertility-control tools together with removals offers the best potential for success. This talk will review fertility-control options for horses, briefly describing intrauterine devices and surgical sterilization, before focusing on immunocontraception. Immunocontraception has the greatest potential to regulate population numbers; however, vaccines must have multi-year efficacy with a single dose to be technically feasible and cost-effective. Immunocontraception works by stimulating the body to produce antibodies that can target gamete production, maturation, function, or outcome. PZP-based immunocontraception is highly tissue-specific, targeting the ovaries, and blocking sperm binding through antibody occupation of ZP receptors on the ova. SpayVac-equid achieves single-dose, multi-year efficacy without boosters, because the antigens are encapsulated within liposomes (multi-layered, submicroscopic vesicles), which gradually release PZP glycoproteins to antigen-presenting cells over an extended period of time. Results from SpayVac trials in several species will be briefly reviewed before focusing on results in horses. Horse studies helped us learn more about the relationship between antibody titers and contraceptive efficacy, as well as potential immune mechanisms of action.

9:30 **Knowledge and Opinions of Federal Management to Control Free-Roaming Horse Populations in the U.S.**

*Nicki Frey[1], Loretta Singleterry[2]*
[1]Utah State University Extension, Berryman Institute, Cedar City, UT.
[2]University of Nevada, Reno, NV.

When enacted in December 1971, the Wild Free-roaming Horses and Burros Act (Public Law 86-234) sought to protect free-roaming horses (Equus caballus) and burros (Equus asinus; i.e. wild horses and burros) on western U. S. public lands from commercial harvest and misuse. However, this law has been controversial since the day it was signed. Several National Research Council reports (1980, 1982, 2013) highlight the need for research into the social context of free roaming horse management, particularly studies that evaluate what aspects of horse management are supported by the public. In 2020, a collaborative group of Extension professionals conducted a national survey of the U. S. public's knowledge and opinion of free-roaming horses, through an online system using a Qualtrics portal; this resulted >5000 responses to 17 sets of questions. We found that there is little understanding of the existing management options that are currently used to management free-roaming horses. Additionally, while the public supported euthanasia as a method to reduce suffering of individual horses, there was less support for using this method to manage overall horse populations. Similarly, they preferred sales and adoptions that have limitations on the final condition of the animal. Finally, there was an emphasis on spending the federal budget on monitoring horse welfare rather than researching horse heath, contraceptives, and horse interactions with other wildlife. We will discuss these results and the influence of demographics on the responses to these topics.

10:10 **Are Mountain Lions Really Eating Feral Horses?**

*Pat Jackson[1], Peter Iacono[2], Dave Stoner[2], Kate Schoenecker[3]*
[1]Nevada Department of Wildlife, Reno, NV.
[2]Utah State University, Logan, UT.
[3]US Geological Survey, Fort Collins, CO.

As of March 1, 2021, the Bureau of Land Management estimated free-roaming feral horse and burro populations exceeding 86,000 on federally managed lands in the West. In May 2018, the New York Times published an article titled, "Let Mountain Lions Eat Horses." The article implies mountain lions (*Puma concolor*) either currently do or could limit feral horse (*Equus caballus*) populations across the western United States. This claim, among others in the article, is not well supported by the existing literature. I will briefly cover the evolution, extinction, and reintroduction of domestic horses to North America, their ecological effects, summarize existing peer-reviewed literature, and the political climate of feral horse management. Based on visits to kill sites from 27 radio marked mountain lions in the arid ranges of southeastern Nevada, approximately 20% of lion diet consists of feral horses. I will also share these preliminary findings.

10:35 **Evidence for Irruptive Fluctuation in Axis Deer of Hawai'i**

*Steven C. Hess[1], Jonathan Sprague[2]*
[1]USDA APHIS Wildlife Services, National Wildlife Research Center, Hawai'i Field Station, Hilo, HI.
[2]Pulama Lanai, Honolulu, HI.

Axis deer (*Axis axis*) on the Hawaiian Islands of Maui, Lana'i, and Moloka'i simultaneously experienced one of the most dramatic population crashes on record in 2021, which coincided with extended drought conditions and prompted an emergency declaration for these islands. This phenomenon has been anecdotally documented during previous drought events, but never formally studied. Newspaper articles document abundant deer becoming a nuisance to agriculture and natural resources, and then experiencing high mortality during droughts. This phenomenon fits Caughley's (1970) operational definition of eruptive (sic) fluctuation "…as an increase in numbers over at least two generations, followed by a marked decline." Deer may increase rapidly during favorable years with high survival and recruitment. During moderate drought, young of the year may experience high mortality, with little recruitment to populations. During severe drought, adults may experience noticeably high mortality. When populations are suppressed by large numbers of removals, fluctuations in mortality may be modulated. Abandonment of large-scale intensive agriculture in recent decades may complicate interpretation but understanding these population processes may lead to better management strategies for axis deer in Hawai'i.

11:00 **Status of the Exotic Mule Deer Population on Catalina Island, California, Based on Annual Spotlight Counts**

*Paul Stapp[1], Emily Hamblen [2]*
[1]California State University, Fullerton, CA.
[2]Catalina Island Conservancy, Long Beach, CA.

Mule deer (Odocoileus hemionus) were first introduced to Santa Catalina Island, California, in 1928, and persist today. Other feral ungulates have been eradicated (goats, pigs) or significantly reduced in numbers (bison) over the past two decades. Successful management of the deer population, including using public hunting, depends upon reliable estimates of population density and demography and knowledge of habitat relationships. We used annual summer spotlight counts, conducted in 8 of the past 10 years, to estimate deer densities in the island interior. In 2021, we also surveyed transects through and around Avalon, the largest town. DISTANCE was used to model density from line transects. Island-wide densities generated in DISTANCE varied from 6.3 to 16.9 deer per km2 between 2012 and 2019, and were positively correlated with September-June rainfall during the preceding year. Most (76-96%) of the identifiable deer were adults and most adults were does (58-76%). Most deer were spotted in island chaparral and coastal sage scrub vegetation, the most common vegetation cover types along transects, but the use of grasslands and man-made habitats varied greatly among years. Data analysis for the 2021 survey is still underway, but the number of deer spotted per kilometer of transect in Avalon was about 3-4 times higher than the number in the undeveloped interior. The high density of deer near Avalon suggests that landscaping and golf courses subsidize deer numbers in town that have the potential to spillover into the more natural areas of the island.

11:35 **Immobilization Efficacy of a Conducted Electrical Weapon in Captive White-Tailed Deer**

*Patrick J. Grunwald[1], Gino J. D'Angelo[1], Mark G. Ruder[2], Lisa I. Muller[3], David A. Osborn[1], Kaitlin O. Goode[4]*
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[2]College of Veterinary Medicine, University of Georgia, Athens GA.
[3]Department of Forestry, Wildlife and Fisheries, University of Tennessee Department of Forestry, Wildlife and Fisheries, Knoxville, TN.
[4]Georgia Department of Natural Resources, Atlanta, GA.

Wildlife emergencies (e.g., injured animals, etc.) often require capture or euthanasia to resolve the situation. Conducted electrical weapons (CEWs) have the potential to immobilize deer for a short duration avoiding potential stressors of extended immobilization (e.g., chemical immobilization) and increasing safety during euthanasia methods (e.g., gunshot). To test the efficacy of CEW immobilization for white-tailed deer, we arranged 5 treatment groups including: 1) 5 deer chemically immobilized and exposed to CEW for 5 seconds, 2) 5 deer chemically immobilized and exposed to CEW for 15 seconds, 3) 10 deer exposed to CEW for 5 seconds, 4) 10 deer exposed to CEW for 15 seconds, and 5) 10 control deer with no chemical immobilization or CEW exposure. We collected blood from deer in treatments 1 and 2 immediately before CEW exposure, and 2-days and 5-days post exposure for serum biochemical analysis (to measure physiological markers associated with organ and tissue damage). We observed deer before, during, and after treatments to evaluate potential behavioral changes. We collected fecal samples daily 15-days pre- and 15-days post-treatment to measure cortisol levels. All deer showed signs of muscle paralysis immediately after exposure to CEW and regained muscle control quickly after the exposure ended. Serum biochemistry results were unremarkable except for significant increase in creatine kinase (CK) 2-days post treatment, suggesting temporary muscle damage. However, CK returned to pre-exposure levels by day 5 among both treatments. After 18 days, 17 of 20 (85%) deer still had CEW probes attached. We detected localized scabbing at all probe sites, however there were no signs of infection or muscle tissue damage. Fecal cortisol analysis is currently underway. Our findings suggest that short-term exposure of a CEW to immobilize white-tailed deer is a potential alternative to typical capture techniques and would provide sufficient immobilization to approach and euthanize a deer.

## Wednesday, March 9 (AM) RODENTICIDE ENVIRONMENTAL FATE AND NONTARGET EFFECTS

8:15 **Anticoagulant Rodenticide Hazards to Predatory Birds: Sublethal Effects, Interpretation of Tissue Residues, and Toxicity Thresholds**

*Barnett A. Rattner*
Eastern Ecological Science Center, U.S. Geological Survey, Department of the Interior, Beltsville, MD.

Over 25 years ago it was stated that "Few modern pesticide groups have such a long history of successful use as the anticoagulant rodenticides" (ARs), and today these compounds are the mainstay of the multi-billion-dollar rodenticide industry. Numerous studies have reported the presence of first- and second-generation ARs (FGAR, SGAR) in non-target birds, with evidence of repeated exposure (i.e., multiple AR residues in an individual). In some locations, a significant fraction of necropsied birds exhibit both liver AR concentrations and presence of hemorrhage consistent with ARs being the cause of death. Studies with captive American kestrels (*Falco sparverius*) have examined chlorophacinone, diphacinone and brodifacoum toxicity (prolonged clotting time, anemia, histopathological lesions, overt signs of intoxication, lethality) and suggest that hawks are more sensitive than commonly used avian test species (bobwhite, mallard duck). We have demonstrated that the SGAR brodifacoum may have long lasting effects on sensitivity to subsequent AR exposure, and global gene expression responses indicate effects extend well-beyond impaired blood clotting. Coagulopathy and reduced hematocrit have been used to document the sequelae of intoxication and to generate diet-based toxicity reference values. An often-cited potentially lethal range for SGARs is >0.1 to 0.2 µg/g liver ww (Newton et al. 1999), and probabilistic analyses using summed SGAR residues suggest a lower lethal range in some species (e.g., 5% likelihood of toxicosis in great horned owl at 0.02 µg SGAR/g liver ww; Thomas et al. 2011). However, the practice of summing hepatic AR residues to assist in diagnosis of toxicosis deserves further attention as there are vast differences in molecular weights (e.g., chlorophacinone 364.8 versus brodifacoum 523.4) and potencies (e.g., median inhibitory concentration of hepatic VKOR activity in kestrels: 5.1 µM for chlorophacinone versus 0.22 µM for brodifacoum) among AR compounds. Despite regulatory changes that sought to limit SGAR use in the U.S., data for raptors do not indicate a downward trend in exposure. Ongoing research and data needs will be discussed. A more complete understanding of the toxicity of ARs in non-target wildlife would enable regulators and natural resource managers to better predict and even mitigate risk.

8:40 **Investigating the Pathways of Rodenticides in Urban Carnivores**

*Niamh Quinn[1], Paul Stapp[2]*
[1]University of California Cooperative Extension, Irvine, CA.
[2] California State University Fullerton, CA.

Anticoagulant rodenticides have been detected in many species of urban wildlife; yet the origins of exposure, route of exposure through the food web, and effects of this exposure on urban wildlife are not well understood. The detection of rodenticide has been the focus of much research but this fails to address many exposure concerns. This failure has led to an inability to improve applications of rodenticides in order to limit exposure of wildlife. Our research in urban southern California has been focused on the question surrounding the pathways of rodenticide from point of application to point of acquisition, using the coyote (Canis latrans) as the top predator in this urban system. We will discuss current results of these research projects and the impacts that they may have on informing policy regarding rodent management and wildlife conservation.

9:05 **Use of Anticoagulant Rodenticides on Farms – Non-Target Exposure and Potential Mitigation**

*Jens Jacob[1], Anke Geduhn[1], Annika Schlötelburg[1], Detlef Schenke[2], Stefan Endepols[3], Nicole Klemann[4]*
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[2]Julius Kühn Institute (JKI), Federal Research Centre for Cultivated Plants, Institute for Ecological Chemistry, Plant Analysis and Stored Product Protection, Königin-Luise-Strasse, Berlin, Germany.
[3]Bayer AG, CropScience R & D, FS - Public Health, Rodent Management and SPP, Germany.
[4]Nicole Klemann, 48231 Warendorf, Germany.

Anticoagulant rodenticides (ARs) are a main tool in commensal rodent management. However, ARs can put non-target species at risk that feed on bait or poisoned prey. We monitored residues in liver tissue of non-

target small mammals, small passerine birds and Norway rats (*Rattus norvegicus*, target species) and identified the locations where poisoned Norway rats died during application of brodifacoum (BR) bait according to best practice guidelines on livestock farms in western Germany. In 54% of 315 non-target small mammals BR was detected when bait was placed in and around buildings but this was reduced by about half when bait application was restricted to indoors only. Similarly, mean BR concentration in non-target small mammals with residues was reduced from 1,409 ±128 ng/g to 617 ±103 ng/g. Arvicoline rodents and shrews were more exposed to BR than voles. BR was present in 30% of 195 birds in 6 of 13 examined species with a mean BR residue concentration of 490 ±169 ng/g. Particularly European robins (*Erithacus rubecula*), dunnocks (*Prunella modularis*), great tits (*Parus major*) and chaffinches (*Fringilla coelebs*) carried BR residues. Mean BR concentration in liver tissue of the target species Norway rat was highest when BR was ingested via bait from bait stations (6,011 ±1,181 ng/g; n=17). 92% of rats (n=71) gavaged with or free-feed on BR died at hidden locations inaccessible to avian or large mammalian predators. 6% of dead rats were found in dense vegetation with limited access for predators and 2% died in open areas. Non-target small mammals and passerines were exposed to ARs applied in standard bait boxes on farms. Bait placement indoors considerably reduced but did not eliminate exposure. Therefore, further effort is required to optimize AR selection and bait application indoors and outdoors. A small fraction of poisoned rats died in the open and these individuals can and should be removed and disposed of to prevent secondary exposure of predators and scavengers.

9:30 **Understanding Anticoagulant Rodenticide Impacts on Demography of a Wild, Free-Living Raptor Population in Landscapes Along an Urban Gradient in Western North America: Preliminary Findings and a Status Update**

*Dave Oleyar[1], Evan R. Buechley[1,2], Jesse L. Watson[1], Jessica Taylor[1], Jennifer Bridgeman[1], Steven Volker[3], David A. Goldade[3], Catherine E. Swift[4], Barnett Rattner[5]*

[1]HawkWatch International, Salt Lake City, UT.

[2]Smithsonian Migratory Bird Center, Washington D.C.

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[4]Liphatech, Inc., Milwaukee, WI.

[5] Eastern Ecological Science Center, U.S. Geological Survey, Department of the Interior, Beltsville, MD.

To inform development of a long-term project we investigated AR exposure in raptor liver samples from carcasses found opportunistically in northern Utah, and also during nest monitoring. We also collected blood samples from wild, free-living adult and nestling American Kestrels (*Falco sparverius*). We detected 5 ARs in liver samples and in 7 of 8 species sampled; and 3 ARs in kestrel blood with higher exposure rates in adults than nestlings. Documenting secondary exposure to contaminants, such as anticoagulant rodenticides, in predator populations is an important first step to understanding potential impacts of pest control measures on non-target wildlife. It is, however, just that—a first step. Knowing exposures happen without understanding their consequences offers little in the way of solutions. Assessing AR levels and impacts in wild populations is challenging and requires a long-term approach to understand whether individual exposures have population-level consequences, on demography, including productivity and survival. Moreover, understanding the cycle of exposure in free-living birds is important, as is identifying potential exposure points on the landscape. For example, do individuals that test positive for ARs once also test positive if additional testing occurs and vice versa? Are individuals that spend more time in certain landcovers (e.g., agricultural or urban settings) more likely to be exposed to ARs, and importantly, if so, does this impact nesting success or survival? We provide an update for ongoing work to address these questions within our long-term research program on American Kestrels in the Salt Lake City metropolitan area in northern Utah. This program monitors kestrels nesting within a network of 500 nest boxes and averages 120 nests annually. We collect blood from a subset of adult and nestling kestrels, and fecal samples from kestrel nests for AR screening. We also track space use by adult kestrels using archival GPS tracking units.

10:10 **Exposure of Urban Coyotes to Anticoagulant Rodenticides in Southern California: Sub-Lethal Effects and Environmental Correlates**

*Paul Stapp[1], Ariana Mc Kenzie[1], Niamh Quinn[2]*
[1]California State University Fullerton, CA.
[2]University of California Cooperative Extension, Irvine, CA.

Secondary exposure to anticoagulant rodenticides (ARs) remains a significant problem for wild carnivores living at the urban-wildland interface. Although direct mortality is the most obvious concern, AR exposure may also cause subtle, sub-lethal effects, such as reduced body condition and increased parasite loads, that ultimately contribute to poorer performance at the population level. However, relatively little is known about such effects on wild animals, or about the environmental factors that contribute to AR exposure. We examined relationships between levels of AR exposure, demographic factors, and landscape variables associated with urbanization, for coyotes (Canis latrans) from urban southern California. AR exposure was estimated from residue assays of livers from 353 carcasses, collected opportunistically between 2015 and 2018. We also conducted veterinary necropsies on a subset of 50 carcasses to investigate effects of AR exposure on body weight, overall condition, and parasite burdens. Nearly all coyotes (98%) contained residues of at least one AR, with second-generation ARs (SGARs) detected in 97%, first-generation ARs (FGARs) detected in 75%, and 66% exposed to both types. Individual coyotes had residues of 0-6 compounds (mode = 4). Coyotes with obvious internal hemorrhage tended to have high concentrations of SGARs, and those exposed to multiple SGAR compounds and with high residue concentrations of diphacinone, the most common FGAR, were in poorer body condition. Very few coyotes (6/353) showed evidence of mange. Contrary to our expectations, landscape patterns suggested higher SGAR residues in coyotes associated with less development, but higher FGAR residues in coyotes in more intensively urbanized areas. ARs are an important tool for managing rodent pests, but given the ubiquitous exposure of coyotes to ARs and evidence of sub-lethal effects, notably from FGARs, we need more information on pathways of exposure and better strategies to reduce the total amount of ARs on the landscape.

10:35 **Investigation Between Anticoagulant Rodenticides and Non-Target Exposure in Breeding Barn Owls**

*Emily Phillips[1], Breanna Martinico[1], Ryan Bourbour[1], Roger Baldwin[1], Sara Kross[2], Joshua Hull[3]*
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[2]Evolution, and Environmental Biology, Columbia University, NYC, NY.
[3]Department of Animal Science, University of California, Davis, CA.

Due to the economically and environmentally beneficial rodent control services birds of prey (raptors) potentially provide, many farmers in the United States and around the world install artificial nest boxes to attract breeding populations of barn owls (Tyto sp.) as part of an integrated pest management (IPM) strategy. However, anticoagulant rodenticides (ARs) are frequently used concurrently to limit damage from rodent pest species in agricultural ecosystems which creates risks of secondary poisoning in beneficial predators. There is a growing body of evidence describing the lethal and sublethal effects of rodenticides in top avian predators, including negative impacts on chick growth, fledging rates, and hunting efficiency. These impacts may ultimately result in a reduction in pest control services from the raptor species farmers attract to their farms. While these issues are receiving increased attention, there is little data describing the circumstances in which barn owls are affected by AR applications in California's agricultural ecosystems and the specific sublethal effects of AR exposure. Here, we gathered AR application methods from farmers who previously erected barn owl boxes on their property and compared them to weekly growth measurements of barn owl chicks. We have found minimal AR exposure in our study area which we hypothesize is due to weather events, rodent population fluctuations, and AR application methods. Our study has shown the need for long-term observations of a population to observe potential patterns for AR exposure, to inform IPM strategies involving barn owls, and to guide future research on the interaction between AR use and raptors.

11:00 **Analytical Challenges to Monitor Anticoagulant Exposure or Poisoning in Animals: Lessons from the Past and New Developments**

*Philippe Berny[1], Lydia Vilagines[1], Valentin Bondoux[2], Corinne Novella[3], Anouk Decors[4], Danièle Vey[1]*
[1]Toxicology, Vetagro Sup, Marcy l'etoile, France.
[2]Vet clinic, Niaux, France.
[3]Laboratoire des Pyrénées, France.
[4]French Agency for Biodiversity (OFB), Wildlife Health Unit, Orléans, France.

Red kites (*Milvus milvus*) are a unique European raptor species, listed in the IUCN Red list of species ("vulnerable"). As an opportunistic scavenger species, it is often exposed to several poisons, including anticoagulant rodenticides. Secondary poisoning with second generation anticoagulant rodenticides (SGAR) is a common feature of this species across Europe. The objectives of this presentation are to present long-term changes observed in SGAR exposure / poisoning in red kites as detected by the Tox laboratory. Regulatory changes in the use of SGARs in France include: 1) limitation of outdoor use for biocidal products in 2014 ; 2) Reduced concentration in baits (<30 mg/kg) and 3) introduction of Zinc phosphide as an alternative for field-rodent control, leading to the ban of Bromadiolone as a crop protection product in December 2020. Analytical changes include the development of LC-MSMS techniques with application starting in 2017 in our lab. Recent trends also include the monitoring of stereo-isomers in residue monitoring. All red kites submitted for SGAR analysis were included in this report. Our results show distinctive features of SGAR exposure / poisoning. In the late 1990s', SGAR poisoning was a common situation, as a result of widespread use of bromadiolone in the fields to control water voles. This situation has changed with the development of information campaigns, monitoring tools to reduce / prevent rodent population outbreaks. SGAR poisoning decreased dramatically. Since 2017, however, more and more Red kites appear to be exposed to at least one SGAR, usually more than one, with lower concentrations and a shift towards SGARS used as biocidal products (i.e against commensal rodents, indoors). Stereoisomers are also discussed, as it has been suggested that toxicity / persistence are associated with certain isomers. Last, using necropsy data a threshold for diagnosis is suggested.

11:35 **Thirty Years of Rodenticide Residue Analysis: How Low is Low Enough?**

David A. Goldade, Steven F. Volker
USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO.

Rodenticides have been used for agricultural and commensal rodent control all over the world. However, non-target and secondary exposures occur from their use. The need to detect these exposures, especially when the residues are at very low levels, have driven the demand for more sensitive and selective analytical methods. Some matrices such as soil or water provide a very straight-forward clean-up while others such as liver or whole carcass present a significant analytical challenge. Some classes of rodenticides are able to be analyzed by highly sensitive fluorescent techniques while others are not. These methods have been continually refined over the years. Over the course of nearly thirty years spent analyzing these compounds, the laboratory at the National Wildlife Research Center has employed a variety of extraction and clean-up methods to meet this need. Techniques employed have included liquid-liquid extraction, solid phase extraction, and, in more recent years, QuEChERS. The analytical instrumentation used has also evolved from large bore liquid chromatography to superficially porous stationary phases and more recently, ultra-high pressure liquid chromatography paired with tandem mass spectrometry. This presentation will focus on reviewing the strengths and weaknesses of these various methods as well as pointing a way towards further refinement of the techniques involved.

## Wednesday, March 9 (PM) RODENTICIDE ENVIRONMENTAL FATE AND NONTARGET EFFECTS

1:25 **Human Exposure to Superwarfarin Rodenticides: Methods of Detection and Treatment**

*Douglas Feinstein[1], Richard B. van Breemen[2]*
[1]University of Illinois; Jesse Brown VA Medical Center, Chicago, IL.
[2]Oregon State University, Corvallis, OR.

In the 1940's, the plant molecule coumarin was identified as the agent in sweet clover responsible for causing hemorrhagic fever in cattle. Warfarin was derived from coumarin in the1940's in a search for anti-coagulants to use as rodenticide. Warfarin inhibits activity of Vitamin K epoxide reductase (VKORC1) needed for recycling

VK, which is critical for coagulation. Warfarin was used worldwide to eradicate rodents, however mutations in VKORC1 arose which reduced warfarin binding and led to warfarin-resistant strains. This led to design of superwarfarins, also referred to as Long Acting Anticoagulant Rodenticides. Superwarfarins have up to 100-fold stronger binding to VKORC1, very long half lives (>20 days), and are extremely toxic. One of the most potent is brodifacoum (BDF) used throughout the world. Unfortunately, as a result there has been an increase in the incidence of poisonings, both accidental as well as intentional. Over 300,000 cases were reported in the USA between 1987-2012, with 90% in children. Fortunately, the amount in bait is low (0.005%) so exposure by this route is treated the same way as for warfarin overdose, provision of plasma and VK1 supplementation for a few days. In contrast, greater accumulation can occur accidentally, for example following aerial dispersal or accidental leakage. Superwarfarins have also been used to cause intentional injury, and this is best illustrated by the outbreak that occurred in the Midwest in early 2018 due to smoking synthetic cannabinoids laced with BDF, which led to hundreds of hospitalizations and numerous deaths. Our work is aimed to develop methods to countermeasure superwarfarin poisoning. I will review our efforts to develop methods to rapidly and sensitively detect superwarfarins in human serum; to identify other VK1-independent effects of these toxins; characterization and distinct properties of BDF isomers, and our attempts to develop 2 already FDA approved treatments to patients.

1:50 **Chiral Liquid Chromatography-Tandem Mass Spectrometric Analysis of Superwarfarin Rodenticide Stereoisomers –Bromadiolone, Difenacoum and Brodifacoum – in Human Plasma**

*Richard B. van Breemen[1], Daniel G. Nosa[1], Douglas L. Feinstein[2]*
[1]Oregon State University, Corvallis, OR.
[2]University of Illinois; Jesse Brown VA Medical Center, Chicago, IL.

Superwarfarins are second-generation long-acting anticoagulant rodenticides that can cause unintended human and wildlife toxicity due, in part, to their prolonged half-lives. Commercially available superwarfarin rodenticides are synthesized as racemates with two asymmetric carbons, producing four stereoisomers. To support studies of human plasma half-lives of individual superwarfarin stereoisomers, a method was developed based on LC-MS/MS to separate and quantify stereoisomers of the commercially important superwarfarins bromadiolone, difenacoum and brodifacoum. Human plasma samples were prepared using protein precipitation and centrifugation. Chiral-phase HPLC separation was carried out on-line with tandem mass spectrometric quantitative analysis of the eluting stereoisomers using selected-reaction monitoring with positive ion electrospray on a triple quadrupole mass spectrometer. All four stereoisomers of each superwarfarin were resolved within 12.5 min with calibration curves spanning 2 – 3 orders of magnitude and lower limits of quantitation between 0.87 – 2.55 ng/mL. This method was used to determine the half-lives of superwarfarin stereoisomers in plasma from patients who inhaled synthetic cannabinoid products contaminated with superwarfarins. These data may be used to guide the development of safer next generation anticoagulant rodenticide stereoisomers.

2:15 **Analyzing for Anticoagulant Rodenticides in Animal Tissue**

*Michael Filigenzi[1], Lori Smith[2], Andriy Tkachenko[3], Cynthia Gaskill[4]*
[1]California Animal Health and Food Safety Lab, UC Davis, CA.
[2]MRI Global, Kansas City, MO.
[3]Center for Veterinary Medicine, United States Food and Drug Administration, Silver Springs, MD.
[4]Veterinary Diagnostic Laboratory, University of Kentucky, Lexington, KY.

Over the last several years, our laboratory has analyzed over 4000 tissue samples taken from various wildlife species for seven different anticoagulant rodenticides (ARs). These analytes include both first and second generation ARs. Many of these samples have been taken from animals living near illegal marijuana grow sites at which large amounts of AR bait are often dispersed indiscriminately to protect plants and infrastructure. Tissue samples were analyzed by solvent extraction, cleanup by dispersive solid phase extraction, and analysis using LC-MS/MS. The method has been collaboratively validated in this matrix with a limit of quantitation of 50 ng/g and calculated detection limits in the range of 0.75 – 25 ng/g. Detections of several of these chemicals in wildlife liver are common, particularly in samples from apex predators such as mountain lions and raptors. In many instances, multiple ARs have been detected in a single sample. Further details of the method, it's ruggedness over the long haul, and some examples of detection of ARs in wildlife samples will be discussed.

2:40 **A Validated LC-ESI-MS/MS Method for Quantifying Multiple Rodenticides in Microscale Samples of American Kestrel Liver, Feces, and Whole Blood**

*Steven F. Volker*
USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO.

The American kestrel (*Falco sparverius*) is a small falcon found throughout North America. Their diet includes rodents, leaving them susceptible to non-target anticoagulant rodenticide exposure. Analytical methods for measuring rodenticide residues have been in use for decades, but often require a large sample size (> 1 g) to achieve adequate sensitivity. To accommodate the smaller quantities of sample available from kestrels, a microscale sampling method (< 1 g or mL) was combined with a highly sensitive and selective LC-MS/MS method for the quantification of multiple rodenticides in liver, feces, and whole blood. Twelve anticoagulant rodenticides (coumafuryl, warfarin, pindone, coumatetralyl, coumachlor, diphacinone, chlorophacinone, bromadiolone, difenacoum, brodifacoum, difethialone, and flocoumafen) and a metabolite of the neurotoxin bromethalin (desmethyl bromethalin) were quantified at parts-per-billion levels. Homogenized liver and feces (0.1 g) were extracted into acetonitrile (ACN) and cleaned-up by dispersive solid-phase extraction (dSPE) using C18 and primary-secondary amine (PSA) sorbents. Whole blood (0.1 mL) was extracted into ACN. Extracts were reduced to dryness, and then reconstituted in mobile phase (ACN/20-mM pH 9.5 ammonium acetate buffer) prior to liquid chromatographic (LC) separation using a 2.1 x 50 mm, 2.5-µm C18 column. The LC was coupled with a tandem mass spectrometer (MS/MS) using an electrospray ionization (ESI) source. Rodenticides were quantified against eight deuterium-labelled rodenticides carried through the extraction process. Method accuracies were on average 96% (liver), 94% (feces), 100% (whole blood). Detection limits were on average 3 ng/g (liver), 7 ng/g (feces), and 0.9 ng/mL (whole blood).

3:20 **Anticoagulant Rodenticide Contamination of Terrestrial Birds of Prey from Western Canada: Patterns and Trends, 1988 – 2018**

*Sofi Hindmarch[1], John E. Elliott[1], Veronia Silverthorn[1], Sandi Lee[1], Victoria Bowes[2], Tony Redford[2]*
[1]Science & Technology Branch, Environment and Climate Change Canada, Delta, British Columbia, Canada.
[2]Animal Health Centre, British Columbia Ministry of Agriculture, British Columbia, Canada.

As the dominant means for control of pest rodent populations globally, anticoagulant rodenticides (ARs), particularly the second-generation compounds (SGARs), have widely contaminated non-target organisms. Here we present data on hepatic residues of ARs in 741 raptorial birds found dead or brought into rehabilitation centers in British Columbia, Canada over a 30-year period from 1988 to 2018. Exposure varied by species, proximity to residential areas, and over time, with at least one SGAR residue detected in 74% of all raptor livers. Multiple SGAR residues were detected in 50% of all raptor livers (n = 368). Barred Owls had the highest incidence of multiple exposure events, with 73% of individuals exposed to two or more SGARs .By comparison, first generation compounds (FGARs) were detected in < 5% of the raptors. Highest rates of exposure were in barred owls (*Strix varia*), 96%, and great horned owls (Bubo virginianus), 81%, species with diverse diets, including rats, and inhabiting suburban and intensive agricultural habitats. Barn owls (*Tyto alba*), mainly a vole (microtus) eater, had a lower incidence of exposure of 65%. Putatively bird-eating raptors also had relatively high incidence of exposure, with 75% of Cooper's hawks (*Accipiter cooperii*) and 60% of sharp-shinned hawks (*Accipiter striatus*) exposed. Concentrations of SGARs varied greatly, for example in barred owls, the geometric mean SGAR = 0.13, ranging from < 0.005 to 1.81 ?g/g ww (n = 208). Barred owls had significantly higher SGAR concentrations than all other species, driven by significantly higher bromadiolone concentrations, which was predicted by the proportion of residential land within their home ranges. Preliminary indications that risk mitigation measures implemented in 2013 are having an influence on exposure include a decrease in mean concentrations of brodifacoum and difethialone in barred and great horned owls, and an increase in bromodialone around that inflection point.

3:45 **Diphacinone and Cholecalciferol (D+C) As A Low Residue Rodenticide**

*Charles Eason[1], Lee E. Shapiro[2], Duncan MacMorran[3], James Ross[1]*
[1]Lincoln University, Lincoln, New Zealand.
[2]Boffa Miskell, Lincoln, New Zealand.
[3]Connovation Ltd, Aukland, New Zealand.

There are marked differences between the potency and pharmacokinetics of different rodenticides. Rodenticides such as brodifacoum are more potent than first-generation anticoagulants. However, their field, farm and outdoor use in urban settings has been linked to bioaccumulation and non-target impacts for more than 3 decades. Product development strategies focused on baits that yield good control of pests without residue risks to wildlife are few. To fill this gap a bait containing a combination of diphacinone at 0.005% and cholecalciferol at 0.06% has been developed as a multispecies bait for NZ use, that is effective at killing rodents and also possums (*Trichosurus vulpecula*), which are resistant to the toxin effects of first-generation anticoagulants. Field trials, each of 200 hectares in size, targeting possums, ship rats (*Rattus rattus*) and mice (*Mus musculus*) achieved an average reduction in abundance of 94% for possums, 94% for ship rats and 80% for mice. These results underpinned the approval of D+C bait by the NZ Environmental Protection Agency in 2019. A new bait is being considered with a lower dose of cholecalciferol. A bait containing ½ or a quarter of the loading concentration of cholecalciferol would have an even better safety profile, for rodent control alone. Early trials indicate that cholecalciferol at 0.03% with diphacinone 0.005% is as effective as brodifacoum as a single exposure bait. Amounts of cholecalciferol as low as 0.015% significantly improve the effectiveness of diphacinone.

4:10 **Identification of *Rattus tanezumi* and Y25F Mutations in The Vkorc1 Gene of *Rattus* Species in Orange County, California**

*Daisey Rangel[1], Mark Janowiecki[2], Niamh Quinn[3], Kassandra Reyes[1], Laura Kreuger[1], Amber Semrow[1]*
[1]Orange County Mosquito and Vector Control District, Garden Grove, CA.
[2]New Orleans Mosquito, Termite and Rodent Control Board.
[3]University of California Cooperative Extension, Irvine, CA.

Roof rats (*Rattus rattus*) are common invasive pests in both urban and agricultural sites as well as a significant public health threat. The use of anticoagulant rodenticides to help control the rodent population poses a risk of developing resistance to these products. Several reports have associated the non-synonymous Single Nucleotide Polymorphism (nsSNP) Tyr25Phe (Y25F) of the vitamin K epoxide reductase subcomponent 1 (Vkorc1) gene to resistance. We conducted a nsSNP screen in the population of Rattus species in Orange County to determine the prevalence of the Y25F nsSNP and found it in half of the sampled rodents. We used tree-based methods using sequence alignments for three mitochondrial DNA regions, cytochrome b, cytochrome oxidase I, and non-coding displacement (D) loop. Species identification using phylogenetic analysis revealed the presence of Rattus populations commonly referred to as *Rattus tanezumi* as well as two haplotypes of roof rats. The Y25F nsSNP was present in both *R. rattus* and *R. tanezumi*. Further genetic testing in Orange County and other areas of Southern California are needed to determine the extent of these Rattus populations as well as the presence of this adaptive trait.

## Wednesday, March 9 (PM) GENERAL SESSION

1:25 **The Moving Target of Feral Pig Management**

*Aaron Sumrall, Field Engine Wildlife Research/Pig Brig, Bay City, TX.*

The sudden adaptability of feral pigs to any given landscape can be frustrating for land and wildlife managers operating under time constraints. Recent research indicates that effective feral pig management must posses the flexibility to alter management week-to-week or day-to-day. Sound feral pig management must take into account the obvious basic life factors, as well as, time, topography, weather conditions and shifts, and sounder dynamics in order to be effective. Land and wildlife managers capable of adapting a management approach as a result of a sudden feral pig shift will have a higher likelihood for desired success.

1:50 **Assessment and Control of Wild Pigs at Hakalau Forest National Wildlife Refuge: Efforts in Progress**
*Kurt VerCauteren, Michael J. Lavelle, Michael P. Glow, Steve Hess*
*USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO.*

Hakalau Forest National Wildlife Refuge (HFNWR) on the Big Island of Hawaii was established in 1987 to protect endangered forest birds and contains many rare and endangered plant and invertebrate species. Native flora and fauna, though, are being impacted and threatened by introduced, invasive wild pigs (*Sus scrofa*). Previous control efforts for wild pigs on the Maulua Unit of HFNWR include trapping and snaring, but information on their ecology and novel approaches to their control are needed. In an ongoing effort, we outfitted 30 pigs with GPS collars and ear tags and initiated the use of novel trap designs and intensified population monitoring methods to track impacts of removals. Using a cost-per-pig approach, we are comparing small portable box traps, large box traps constructed on site, corral traps with traditional swing gates or novel tarp gates, and novel PigBrig® net traps. We are implementing three removals along with spatially explicit capture-recapture population estimates and a novel density index to track effects of removals. We completed our first removal which entailed 94 capture events with 223 individuals captured. Using capture data, we calculated a cursory Lincoln-Petersen mark-recapture population estimate of 354 pigs initially, leaving 149 pigs remaining. Thus far, PigBrigs are most productive with an average of 8.47 pigs captured and portable box traps were the least productive with an average of 3.00 pigs. However, pigs caught in portable box traps minimize cost at $12.29/pig, emphasizing their efficiency. Conversely, pigs caught with corral traps with tarp gates are roughly 4 times more costly ($48.94). Collection and analyses of data are ongoing, up to date preliminary results will be presented. As we conduct additional removals, we will document how success declines by trap type and cost per pig increases as their density on the landscape declines.

2:15 **Pest Friends, a Board Game Simulation of Pest Management**
*Grant D. Loomis, Jason Thomas*
*University of Idaho, Hailey, ID.*

To provide a game-based learning experience, we developed a board game that allows players to practice the principles of IPM and experience consequences of choices. The game is centered around a bag known as the field containing a variety of tiles representing the crop or organisms like vertebrates living in the field. In the game, players take on the role of a team of pest managers who oversee managing pests in a fictional crop. The game is played in 8 rounds represented by months. Players are allotted a limited supply of money and actions which can be used to carry out certain actions. Over the course of the game, vertebrates will colonize the field entering the bag. As players make decisions and the field composition changes, crops can become damaged or devastated. For players to be successful they must use some of their actions each round to scout, which allows them to gain information about their field composition. As players encounter new organisms, they can research them to gain more information about their biology and management techniques. Players can also use actions to deploy pesticides or modify the habitat thus affecting different types of vertebrates. At the end of each round, vertebrates will reproduce and feed, damaging either plants. The facilitator carries out consequences of player actions and changes the composition of the field behind a screen.

2:40 **Small Rodent Communities and Their Associated Damage to Wheat-Groundnut Agriculture Systems**
*Nadeem Munawar, Tariq Mahmood*
*Department of Wildlife Management, PMAS-Arid Agriculture University, Rawalpindi, Pakistan.*

Rodents can cause significant damage to wheat-groundnut crops in developing countries, as well as to stored produce and infrastructure, affecting food security and income of small-holder farmers. Wheat (*Triticum aestivum*) and groundnuts (*Arachis hypogea*) are important cash crops for local farmers in Pakistan. Field experiments were performed to assess the extent of rodent damage to wheat-groundnut crops throughout their growth stages (i.e, germination, flowering/peg formation and maturity) in the agro-ecological zones of Pothwar Plateau, Pakistan. We used a quadrat method to record the number of damaged crop plants. On the basis of the trapping data four rodent species were captured from wheat-groundnut cropping systems which were responsible for causing damage, i.e., lesser bandicoot rat (*Bandicota bengalensis*) was the mainly prime species approached by the short-tailed mole rat (*Nesokia indica*), the Indian gerbil (*Tatera indica*) and the bush rat (*Golunda ellioti*). In both crops, the maximum damage was recorded at crop maturity (10.7 and 14.4%, respectively). The lowest reported damage to wheat and groundnuts was at the germination stage (3.5% and

6.0%, respectively). The lower damage reported at germination could be due to availability of non-crop vegetation at field borders that may be a potential factor influencing damage. Our findings clearly show the considerable amount of damage caused by rodents to wheat-groundnut at maturity across all the agro-ecological zones of Pothwar and indicated that the small mammal composition was more related to maturity stage/season of crops, when the availability of food and climatic condition were favorable and having security under crop shelter. More detailed studies are needed to fully understand the population and breeding ecology of the relevant rodent pest species in relation to damage patterns to optimize management beyond individual structural measures.

## Thursday, March 10 (AM) VERTEBRATE PESTICIDES

8:15 **A 2021 Review of Sodium Fluoroacetate for Conservation and Protecting Endangered Species**
*Charles Eason, James Ross*
Lincoln University, Lincoln, New Zealand.

Sodium fluoroacetate (1080) is a vertebrate pesticide principally used to control unwanted introduced mammals in New Zealand and Australia. There have been over 260 publications during the last ten years on 1080 which supplement a body of scientific information regarding mode of action, natural occurrence, toxicology, antidotes, metabolism and fate in the environment. Multi-year studies have explored long-term outcomes, for multiple native bird species. Numerous reviews on community attitudes stimulated, in part by the Predator Free New Zealand (PFNZ) 2050 campaign, conclude that 1080 use for conservation remains controversial. Further effort is needed to increase target specificity avoiding game species and employ approaches with the highest public acceptance, including hunting, trapping and eradication strategies that obviate the need for repeated use of toxic baits. Greater acceptance of large-scale use of any pest control is likely when long-term goals and strategies for ecosystem recovery employ toxins as one-off treatments for eradicating pests versus continued applications.

8:40 **Efficacy of BurrowRx to Treat Black-tailed Prairie Dogs (*Cynomys ludovicianus*) in Montana: A Pilot Study**
*Stephen M. Vantassel*
Montana Department of Agriculture, Lewiston, MT.

In recent years, there has been increasing interest in the use of carbon-monoxide generating devices to control burrowing rodents. A pilot study was performed to determine how long a black-tailed prairie dog (*Cynomys ludovicianus*) burrow needed to be fumigated to obtain control. Data was collected regarding the number of entrances a burrow system had as well as the maximum distance between connected holes. Insights were drawn as to the impact burrow system size had on fumigation efficacy as well as thoughts on improving treatment efficiency.

9:05 **Development of a New Coyote Toxicant**
*Katherine Horak[1], Julie Young[2], Adam Mitchell[1], Jason Bruemmer[1]*
[1]USDA/APHIS/Wildlife Services, National Wildlife Research Center, Fort Collins, CO.
[2]Depart of Wildland Resources, Utah State University, Logan, UT.

Research on the potential use of para-aminopropiophenone, PAPP, to control pest wildlife began decades ago; the United States Department of Agriculture has been involved in PAPP research since its beginning. PAPP has been registered in New Zealand for the control of stoats and feral cats and in Australia for the control of wild dogs and foxes. The National Wildlife Research Center (NWRC) has maintained an interest in the development of PAPP for coyote control. NWRC investigated the efficacy of PAPP as a means of lethal control in coyotes using multiple routes of administration. In initial studies, animals were orally gavaged with PAPP in an inert carrier to determine LD50 values and test LD100 doses. Coyotes were also offered PAPP in meatballs and allowed to freely consume the food bait. In further trials, NWRC researchers tested the effectiveness of two different doses of toxicant PAPP capsules (880 mg and 400 mg) placed in a spring-loaded ejector device (SLED) to lethally control coyotes. Captive coyote trials occurred at NWRC's headquarters and Utah Field Station. Both

doses were 100% lethal to all animals tested. A larger study is planned for 2022 using 400 mg doses and wild-caught coyotes fitted with GPS collars which will allow researchers to monitor coyote activity and movement patterns.

9:30 **The Path to U.S. National Registration of a Toxicant Product for the Control of the Small Indian Mongoose**

*Carmen C. Antaky, Steven C. Hess, Emily W. Ruell, Israel L. Leinbach, Shane R. Siers, Robert T. Sugihara*
USDA, APHIS, WS, National Wildlife Research Center, Hawai'i Field Station, Hilo, HI.

The small Indian mongoose (*Urva* [syn. *Herpestes*] *auropunctatus*), is a highly invasive species in its introduced range that negatively impacts ecosystems by depredating native species, serving as a vector of disease posing a risk to human health, and creating sanitation issues in food processing facilities and public areas. Introduced for biocontrol in the late 1800s in Hawai'i and the Caribbean, mongooses currently have well-established populations across multiple islands in both island archipelagos. The concern of accidental transportation between mongoose-occupied and mongoose-free islands, difficulty in species detection, and high cost and labor demand of trapping present the need for an alternative control method. A target-specific and efficacious toxicant can provide an additional tool to reduce mongoose abundance, to eradicate incipient populations, and for biocontrol at ports of entry. In this paper, we document the pathway to registration for a toxicant product for mongoose control with the U.S. Environmental Protection Agency. A registered product must demonstrate a low risk to nontarget species, meet standards for human health and safety, and show no unreasonable adverse effects to the environment. There are no other comparable invasive, small, mammalian carnivores for which toxicants have been developed and registered for bait station deployment in the United States.

10:10 **Rodent Contraceptives in Poultry Farms**

*Courtney Ray, Brandy Pyzyna*
SenesTech, Inc., Phoenix, AZ.

Agricultural operations attract and harbor large populations of rats due to abundance of resources. An integrated pest management (IPM) program is imperative in farming operations for the health of the animals, employees, and consumers. ContraPest®, a liquid contraceptive bait that targets the reproductive output of male and female Norway and roof rats, can be an effective method of control in these environments. If used in tandem with other pest control measures, ContraPest can accelerate rat population declines and maintain low numbers by reducing birth rates. ContraPest was deployed for 16 months at an egg production farm in the United States as part of an IPM program. Rat populations were surveyed via camera traps before, during, and after the deployment of ContraPest. Since fertility control reduces population size by preventing new rats, as opposed to removing them, the number of juvenile rats captured in photos was analyzed to assess population recruitment. Preliminary analysis shows that the total number of rats photographed during camera surveys decreased from 349 rats to 15, with a general index of rat activity decreasing 95%. The number of juveniles captured on camera decreased from 55 to 1 (98%. reduction). Rat activity increased after ContraPest was removed, indicating a rebound in fertility. Despite the recovery in numbers after fertility control treatment ceased, rat activity remained 54% lower than levels measured prior to the implementation of ContraPest. These data suggest that rodent control programs can be enhanced by the addition of ContraPest and that the effects of fertility control can provide sustained control.

10:35 **The Economic, Social and Political Impact of the California Ecosystems Protection Act**

*Dr. Loretta Mayer, Thomas K. Ohmart, Cheryl A. Dyer*
FYXX Foundation, Flagstaff, AZ.

California Assembly Bill 1788 and establishment of the California Ecosystems Protection Act indicates the evolution of public opinion regarding rodent management products is moving away from the use of poison. Similar actions have taken place in the province of British Columbia and the state of Massachusetts, with initiatives in the states of Washington and Connecticut. These events signal a trend in pest management that requires attention. There are many aspects of California's law that will require further refinements such as enforcement, best practices, and the economics of the action. The FYXX foundation 501c(3) non-profit organization has undertaken to assess these elements of alternate rodent IPM programs including any offsetting benefits of public and employee perceptions. Data was collected from three sites: two animal

sanctuaries and a large commercial business district. Strategies were as follows; site #1, an IPM program including exclusion, fertility control, repellents, station monitoring with relocation and reduction; site #2 IPM including exclusion, fertility control, monitoring and station relocation, and site #3, IPM including station lure baiting followed by targeted fertility control, and monitoring. All data were analyzed with review by professional pest managers, facility management personnel, municipal agencies, and FYXX staff. Employee interviews and surveys indicated that there was a scepticism at initiation of the study, however, by month #3 a reversal to strong support for the new program and high satisfaction with a poison-free facility. Site Population Reduction Product Reduction Cost Reduction* Length of Study#1 92% 97% 84% 22 months#2 90% 91% 84% 21 months#3 N/A 74% 50% 4 months*Includes product, applicator travel and labor. These data indicate that collaborative work between product manufacturers, professional pest managers, and users can provide new alternatives to IPM programs that are economically sound, socially, and politically responsive to a new trend in pest management.

## Thursday, March 10 (AM) GENERAL SESSION

8:15 **Can Nest Boxes in Napa Valley Winegrape Vineyards Sustain a Local Population of American Barn Owls (*Tyto furcata*)?**

*Jaime E. Carlino, Mathew D. Johnson, Laura M. Echávez, Samantha D. Chavez*
Department of Wildlife, Humboldt State University, Arcata, CA.

Research worldwide suggests that the use of nest boxes for barn owls can contribute to rodent pest removal as part of an integrated pest management (IPM) system. Most of this research has focused on understanding this system from the farmers' perspective, by quantifying how many rodents barn owls remove and where farmers can deploy nest boxes to maximize pest control benefits. However, the question of whether the installation of nest boxes benefits barn owl populations in agricultural ecosystems remains unanswered. We addressed this knowledge gap by examining whether nest boxes in winegrape vineyards are exploitative, or if they offer a mutually beneficial conservation and management technique. This question has obvious practical application to farmers because a reliable, long-term source of barn owls and the ecosystem services they provide rests on the assumption that the nest boxes help maintain a viable local population. We used a simple demographic population model to evaluate the viability of this population using the finite rate of increase. Empirical estimates of female reproductive success were measured based on the number of live offspring at 50 days after the first hatched. Average reproductive success coupled with conservative estimates of adult and juvenile (post fledging) survival obtained from the literature resulted in 1.06. Based on traditional interpretations of this population is self-sustaining and slightly increasing. To account for uncertainty in survival estimates and variation in reproductive success among years, we conducted a sensitivity analysis guided by the range of survival estimates found in the literature. Results provide estimates of the minimum adult and juvenile survival required to sustain a local population when combined with our estimates of reproduction. Future research should estimate barn owl survival in California winegrape vineyards and provide additional documentation of reproductive success in other locations and years.

8:40 **Mainland Eradication of the Invasive Raccoon Dog (*Nyctereutes procyonoides*) and the Evolution of a National Task Force for Invasive Alien Species**

*P-A Åhlén*
Swedish Association for Hunting and Wildlife Management, Ånäset, Sweden.

Invasive Alien Species (IAS) are recognized as one of the main threats to global biodiversity. According to EU-regulation 1143/2014 on IAS, EU-listed species has to be managed, preferably eradicated, by the concerned member states. In Sweden we have approximately 17 out of the 49 EU-listed IAS established or occasionally seen in the country. Out of those 17, 7 are mammals, birds or water turtles (*Trachemys spp.).* The Swedish Raccoon Dog Project has been ongoing since 2008, with the goal to minimize the occurrence of the Raccoon Dog in northern Sweden, where it is invading from Finland, and stop it from dispersing south and west. The Swedish Association for Hunting and Wildlife Management is leading the project in Sweden, contracted by the Swedish Environmental Protection Agency (SEPA). The management has been very successful, and today the raccoon dog population is under control. The management framework for the raccoon dog is very adaptable, with a core of full time employed professional hunters. Many of the tools developed for the raccoon dog can

also be used on other species. To keep the competence of the professional staff SEPA has taken the decision to, instead of lowering the projects resources (since the raccoon dog now needs less work), broaden the mission to cover all mammal and bird IAS, plus water turtles, in the country. In 2014 the raccoon (Procyon lotor) was added to the mission, in 2018 the muskrat (*Ondatra zibethicus*), and in 2019 the Egyptian goose (*Alopochen aegyptiaca*) and water turtles (Trachemys scripta sp.). The task force should also stand on hold and be prepared to take care of all new mammal and bird IAS discovered in the country. Apart from the EU-listed species, SAHWM also works with eradication of American mink (*Neovision vision*) in valuable bird recruitment areas and from 2021 we have the mission to eradicate a small population of Stone Marten (*Martes foina*) that has emerged in an urban area in Southernmost Sweden. As a prerequisite for a successful IAS management, SEPA has given the project necessary exemptions from the hunting law and permission to work on all land in the country, even if the land owner does not agree. Outside of Europe the project has been a key part of two successful eradications of Common Myna (*Acridotheres tristis*) on different islands in the Seychelles. The management cost for mammal and bird IAS for the state has dropped from of approx. € 800 000 annually for one species in 2008-2013 to approx. € 100 000 per species today. The national task force for eradication of invasive alien mammals and birds has proven both practically and economically successful in Sweden and could be used as a template for other countries.

9:05 **The Wildlife Affordances of Urban Infrastructure: Towards A Multispecies Commons**

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Landscape affordances, or what the environment offers an animal, are inherently species-specific to the extent that each taxon has unique needs and responses to landscape characteristics. Wildlife responses to landscape features range on a continuum from avoidance to attraction and quantifying these habits are the backbone of wildlife movement ecology. In anthropogenically modified landscapes, many taxa do not occupy areas heavily influenced by humans, while some species seem to flourish, such as coyotes (*Canis latrans*) and pigeons (*Columba livia*). Sufficient overlap in landscapes designed for human purposes (e.g., freeway underpasses, channelized waterways, and cemeteries) but which are also suitable for wildlife (e.g., by providing sources of food, shelter, and refuge) underlies wildlife persistence in urban areas and is increasingly important in the world's largest metropoles. Studying these overlapping worlds of humans and wildlife in cities provides a rich foundation for broadening human perceptions of cities as ecosystems that exhibit emergent hybridity, whereby certain anthropogenic features of urban landscapes can be used by wildlife even as they maintain their utility for humans. By examining the scaling dynamics of the infrastructural signature, the phenomena of urban wildlife movement patterns conforming to the shapes of human infrastructural forms, we hope to expand on prior research in wildlife landscape ecology by stressing the importance of understanding the overlapping worlds of humans and wildlife. Further knowledge of the urban ecological commons is necessary to better design cities where emergent hybridity is leveraged toward the management goals of reducing human wildlife conflict and promoting biodiversity.

9:30 **The Red Queen and the Brown Treesnake: Moving Targets for Management of One of the World's Most Harmful Invasive Reptiles**

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"Now, here, you see, it takes all the running you can do, to keep in the same place." The Red Queen in Lewis Carroll's "Through the Looking Glass" has become a common metaphor for striving to reach a goal only to see it move further away the harder you try. For decades, the prospect of landscape-scale suppression of invasive Brown Treesnakes, and reduction of the damage they caused, seemed impossible. Our discovery of a relatively safe and effective oral toxicant and engineering of an automated system for aerial bait applications made significant progress in this direction. However, these tools are less effective for very large snakes, which take larger prey and contribute the most to reproduction. Prior to the late 1990s, live Brown Treesnakes were found on other islands in incoming cargo from Guam at an alarming rate. Since the inception of a coordinated

and comprehensive interdiction program, no live snakes have been found in cargo from Guam, a tremendous conservation accomplishment. Unfortunately, southern Guam has not been included in intensive biosecurity efforts and a population of Brown Treesnakes was discovered on the offshore islet of Cocos in 2020. Previously snake-free, Cocos provided refuge for several species of concern that were extirpated from mainland Guam by Brown Treesnake predation. Research on Cocos indicates that baiting and trapping, useful snake removal methods on Guam, are ineffective in the presence of abundant live prey. Our confident strides in interdiction and management of Brown Treesnakes have been partially set back by unanticipated obstacles and developments. We will conclude our review of recent developments by replacing this pessimistic Red Queen metaphor of "one step forward, two steps back" with a more optimistic and realistic "two steps forward, one step back," which is arguably the fundamental experience of all vertebrate pest control efforts.

10:10 **Free-Roaming Cat Management: Be Careful What You Wish For**
*Peter J. Wolf*
Best Friends Animal Society, Kanab, UT.

Despite the popularity of the domestic cat (*Felis catus*) as a pet, free-roaming cats are often targeted for "predator management." Indeed, the authors of Cat Wars: The Devastating Consequences of a Cuddly Killer argue that, "from a conservation ecology perspective, the most desirable solution seems clear—remove all free-ranging cats from the landscape by any means necessary." Setting aside the significant challenges associated with such a "solution" (and its thorny ethical issues), it is worth considering the potential consequences. On Marion Island, for example, home to the world's largest successful cat eradication campaign, a population of "killer mice" now threatens the very seabirds whose protection was used to justify the 19-year eradication effort. Although eradicating mainland populations of free-roaming cats is far less likely, a campaign to kill an unprecedented number of domestic cats—typically in the name of protecting wildlife and public health—continues in the U.S. Meanwhile, efforts to manage their numbers through targeted sterilization programs are routinely opposed by supporters of lethal management. It is not at all clear, however, how impeding such efforts would benefit wildlife or public health. On the contrary, undermining sterilization programs is likely to result in more free-roaming cats, not fewer. And feeding bans, often endorsed by supporters of lethal methods for managing free-roaming cats, make it more difficult to trap cats—again, the likely result being more free-roaming cats. Unfed cats are also more likely to resort to hunting for survival, thereby increasing their threat to wildlife—and their likelihood of becoming infected with (and potentially spreading) the Toxoplasma gondii parasite. In this presentation, I will make an evidence-based argument that attempts to manage free-roaming cat populations using lethal methods are generally counterproductive.

10:35 **Decision-Making for Foraging in Response to Auditory Stimuli in Wild-Caught Jungle Crows**
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In Japan, the Jungle crow *Corvus macrorhynchos* is one of the most common problematic birds causing significant economic damage. Previous attempts at crow control have been generally unsuccessful, but the mechanisms involved are not well understood. In this study, to clarify their sensitivity to noise, we investigated the foraging behavior of wild-caught Jungle crows when auditory stimuli were presented at their feeding sites. The auditory stimuli consisted of either a low-tone in the crow's audible range (0.5–10 kHz) or a high-tone outside the audible range (>10 kHz), based on pink noise. In Experiment 1, one feeding site was set up in a U-shaped experimental cage, and experiments were conducted under three conditions (low or high experimental sound presented at 80 dB sound pressure or silence). In Experiment 2, feeding sites were set up at both ends of the cage, and the low-tone stimulus was presented at a sound pressure of 80 dB only at one of the feeding sites. All experiments were conducted with one individual crow at a time. The results of Experiment 1 showed that in both sound conditions, as well as in the silent condition, all the individuals started foraging in the presence of the sound and there was no clear difference in foraging behavior. However, in Experiment 2, the amount of food foraged in the feeding area under the silent condition was significantly higher than that in the feeding area where the low tone stimulus was presented. Our results suggest that Jungle crows living in urban areas have a high noise tolerance, and they choose to avoid auditory stimuli only when similar benefits can be obtained at other sites. Therefore, when dealing with Jungle crows, it is important to consider not only how to scare them, but also where to direct them.