Wildlife Services

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Methods and Strategies for Controlling Rabies

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Groups Affected By These Problems:

- Consumers
- Livestock producers and farmers
- Public Health officials
- Sporting organizations
- U.S. citizens
- Veterinarians
- Wildlife and natural resource managers

Major Cooperators:

- Artemis Technologies
- Centers for Disease Control and Prevention
- Colorado State University
- Global Alliance for Rabies Control
- Kansas State University
- Lyssa, LLC
- MERIAL, Inc., Sanofi-Pastuer
- New Mexico State University
- Purdue University
- SmartVet Inc.
- Texas A&M University
- Texas State Department of Health Services
- University of Georgia
- University of Tennessee
- USDA/APHIS/Wildlife Services Operations

National Wildlife Research Center Scientists Develop New Methods, Strategies to Reduce Rabies Transmission from Infected Wildlife to Humans, Domestic Animals, and Wildlife

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

Increased urbanization, greater acceptance of and desire for living closer to free-ranging wildlife, and burgeoning wildlife numbers have led to increased conflict between people and wildlife. Such conflict can take many forms, including disease transmission among wildlife, livestock, and humans. Indeed, many pathogens that cause animal disease also are capable of causing disease in humans so understanding the processes mediating disease transmission among wildlife, livestock, and humans is needed.

Rabies is an acute, fatal viral disease, most often transmitted through the bite of a rabid mammal, which can infect people, domestic pets, livestock and wildlife. Impacts to society from this and other wildlife diseases can be great. For instance, the cost of detection, prevention, and control of rabies in the United States exceeds $300 million annually.

In 2000, the Secretary of Agriculture enacted a Declaration of Emergency for rabies, citing threats to livestock and to public health and safety. In 2001, NWRC initiated research to help reduce rabies transmission.

In the United States, terrestrial rabies can be found in wild animals, including raccoons, skunks, gray foxes, arctic foxes, bobcats, and coyotes. In an effort to halt the spread and eventually eliminate terrestrial rabies in the United States, NWRC scientists are researching the behavior, ecology, movement, and population structure of raccoons and other wildlife hosts. They also are evaluating methods and techniques used to vaccinate wildlife against rabies to decrease the risk of transmission and maintenance in the wild.

Applying Science & Expertise to Wildlife Challenges

Forecasting the Spread of Raccoon Rabies. — In the United States, wildlife accounts for 92 percent of all reported rabies cases. The raccoon rabies virus variant is responsible for significant spillover infection into dogs, cats, and other wildlife. Following the relocation of raccoons from Florida to Virginia during the 1970s, 80s, and 90s, raccoon rabies has spread and is now prevalent throughout the eastern United States. An extensive collaborative oral rabies vaccination (ORV) program led by WS has been established to take advantage of geographical features (e.g., the Appalachian Mountains, the Great Lakes, large rivers) and help prevent westward spread of rabies.

The benefits of maintaining the ORV zone are significant for public health, agricultural, economic, and wildlife management reasons. Specific benefits include reductions in human post-exposure prophylaxis, reduced livestock and pet losses, and protection of wildlife resources. To better quantify ORV program benefits, NWRC researchers and partners modeled the spread of raccoon rabies over 20 years in the absence of current ORV activities. The forecast models incorporated three different rates of spread - low (15 kilometers [km]/year), medium (30 km/year), and high (60 km/year) - based on historical rates of raccoon rabies spread in the eastern United States. Over the 20-year horizon, spread would extend as far west as the Texas border and western Iowa. Over a longer period, the spread would likely continue to the Rocky Mountains, where harsh winters and unsuitable habitat might stop its spread. Such forecasting information aids managers in determining the costs and benefits associated with ORV programs.

Modeling Climate Change Impacts on Fox Rabies in Alaska. — Scientists predict the northern and southern reaches of the earth, such as the Arctic, will be more susceptible to climate change. The Arctic fox variant of rabies virus circulates in Arctic foxes, with significant spillover into red foxes in Alaska, and most reported domestic and wildlife cases occur in northern and western coastal areas. Cases of rabid foxes peak in winter and spring. NWRC researchers and partners modeled the impacts of warming climates on

the prevalence and spread of fox rabies in Alaska. As temperatures increased, models predicted a stronger seasonal effect on Arctic fox rabies at higher latitudes. However, as temperatures continued to rise, the primary reservoir of rabies in Alaska shifted from Arctic fox to red fox. Researchers conclude that more information on fox and lemming populations, in addition to surveillance of fox rabies, will be critical to understanding the future spread of the Arctic fox rabies variant in North America.

Improving the Formulation for Rabies Vaccines. — In North America, wildlife reservoirs maintain rabies. To reduce the prevalence of rabies, RABORAL V-RG ORV baits are distributed to wild carnivores in the United States east of the Appalachian Mountains, and portions of Ohio, Arizona, New Mexico, and Texas. Improvements to bait uptake and seroconversion (successful vaccination) are sought to improve the cost-effectiveness and efficiency of the ORV program. The RABORAL V-RG vaccine is delivered as a liquid in a plastic sachet. Under optimal conditions, when an animal's teeth pierce the sachet, the vaccine is released into its mouth and absorbed. Foxes and coyotes tend to pick up the entire bait with their mouths, releasing a full dose of vaccine as they chew. Raccoons and skunks hold the vaccine sachet on the ground and bite only small portions at a time, allowing the open sachet to leak. Pen trials have repeatedly shown that raccoons and skunks spill much of the liquid in the sachet. NWRC researchers evaluated the possibility of using two benign compounds, chitosan and N,N,N trimethylated chitosan (TMC), that could act as adjuvants to intensify the animals' immune responses and make the vaccine more viscous, which helps ensure the raccoons ingest it more readily. (Chitosan is deacetylated chitin, a nontoxic polymer naturally occurring in crustaceans, insects, and mushrooms. When chitin is converted to chitosan, it becomes a gelatinous precipitate that enhances the transport and absorption of vaccines or drugs.) In pilot studies with captive raccoons, adding TMC to RABORAL V-RG allowed raccoons to consume baits more easily and without leakage or interference with the vaccine's effectiveness. These encouraging results have led to joint patent development with the private sector and will cause further product enhancement and evaluations of raccoon vaccination success rates.

Evaluation of ONRAB Bait Flavors for Coyotes, Mongooses, and Domestic Dogs. — The spread of rabies in wildlife throughout the United States is primarily controlled through ORV. Researchers have sought new vaccines to improve bait acceptance and vaccination (seroconversion) rates in some target species. In Canada, ONRAB Ultralite bait (Artemis Technologies, Inc.) is a new rabies vaccine used for raccoons and skunks. Preliminary field trials suggest this bait may be a useful tool for ORV in the U.S. In a series of studies, NWRC researchers determined the ONRAB flavors that coyotes, mongooses, and domestic dogs accept and prefer. Coyotes chose fish- and cheese-flavored baits more frequently than bacon and sugar-vanilla flavors; mongooses selected cheese- and fish-flavored baits more frequently than those flavored with coconut. Flavor preference tests with domestic dogs covered seven bait flavors (bacon, cheese, dog food, hazelnut, sugar-vanilla, peanut butter, and sardine). Dog food was selected first 56 percent of the time and more frequently than any other type of bait. Bacon, cheese, and sardine flavors were selected with a similar frequency to that of dog food. Researchers note that selection of an appropriate bait flavor for ORV programs may depend on location and both target and non-target animal populations.

Optimizing ORV Vaccination Timing for Young Raccoons. — The WS' National Rabies Management Program works to control the spread of rabies in terrestrial wildlife by distributing oral rabies vaccination (ORV) baits. RABORAL V-RG (V-RG, Merial Inc.) is currently the only effective oral vaccine licensed for use in free-ranging raccoons and coyotes in the United States. However, vaccinating young animals can be problematic because they lack fully developed immune systems and harbor temporally transient maternal antibodies that may interfere with vaccination. Knowing the antibody status of young raccoons is important in developing optimal timing of ORV during the raccoons' annual cycle. In captive raccoon studies, NWRC researchers monitored the antibody responses of very young raccoons to RABORAL V-RG and subsequent rabies vaccine exposure. Researchers found not only that vaccinated young raccoons had antibody responses to the RABORAL V-RG vaccine, but that some unvaccinated raccoon kits had them as well, likely due to contact with vaccinated littermates. At approximately nine months of age, all kits were inoculated with a different rabies vaccine. Kits that initially responded to the RABORAL V-RG oral vaccination or contact with vaccinated littermates had a rapid antibody response. In contrast, the RABORAL V-RG non-responders and those with acquired maternal antibodies had substantially lower rabies-virus-neutralizing antibody levels. These findings suggest that very young naive raccoons are able to mount immune responses following oral or indirect exposure to RABORAL V-RG, but the presence of maternal antibodies may interfere with immune response to vaccination. Thus, distribution of ORV baits in the fall (i.e., post-weaning when maternal antibodies are no longer present) appears to be the optimal time for successful vaccination of young raccoons.

Selected Publications:

Beasley, J.C., W.S. Beatty, T.C. Atwood, S.R. Johnson, and O.E. Rhodes, Jr. 2012. A comparison of methods for estimating raccoon abundance: Implications for disease vaccination programs. Journal of Wildlife Management 76(6): 1290-1297.

Fry, T.L., K.K. VanDalen, C. Duncan, and K. Vercauteren. 2013. The safety of ONRAB in select non-target wildlife. Vaccine 31: 3839-3842. doi: 10.1016/j.vaccine.2013.06.069.

Fry, T., K. Van Dalen, J. Hurley, and P. Nash. 2012. Mucosal adjuvants to improve wildlife rabies vaccination. Journal of Wildlife Diseases 48: 1042-6. doi: 10.7589/2011-11-331.

Kim, B.I., J.D. Blanton, A. Gilbert, L. Castrodale, K. Hueffer, D. Slate, and C.E. Rupprecht. 2014. A conceptual model for the impact of climate change on fox rabies in Alaska, 1980-2010. Zoonoses and Public Health 61:72-80. doi:10.1111/zph.12044.

Slate, D., R. Chipman, T. Algeo, S. Mills, K. Nelson, C. Croson, E. Dubovi, K. VerCauteren, R.W. Renshaw, T. Atwood, S. Johnson, and C. Rupprecht. 2014. Safety and immunogenicity of Ontario rabies vaccine bait (ONRAB) in the first US field trial in raccoons (Procyon lotor). Journal of Wildlife Diseases 50(3):582-595. doi: 10.7589/2013-08-207.

Major Research Accomplishments:

- WS modeled the spread of raccoon rabies in the absence of current ORV activities. If left unchecked, in 20 years, the virus could spread as far west as the Texas border and western Iowa.
- WS researchers and partners modeled the impacts of warming climates on the prevalence and spread of fox rabies in Alaska.
- WS research found the addition of N,N,N trimethylated chitosan to RABORAL V-RG rabies ora vaccines allowed raccoons to consume baits more easily and without leakage and did not interfere with the vaccine's effectiveness.
- WS studies determined that coyotes and mongooses prefer fish and cheese flavored ONRAB baits.

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