Methods and Strategies for Controlling Rabies

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Groups Affected:

- 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
- IDT Biologika, GmbH
- Kansas State University
- Lyssa, LLC
- MERIAL, Inc., Sanofi-Pastuer
- Northern Arizona University
- Texas State Department of Health Services
- University of Georgia
- 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 people.

Rabies is an acute, fatal viral disease, most often transmitted through the bite of a rabid mammal, which can infect people as well as 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 the spread of rabies.

In the United States and its territories, terrestrial rabies can be found in many wild animals, including raccoons, skunks, gray foxes, arctic foxes, bobcats, coyotes, and mongooses. In an effort to halt the spread and eventually eliminate terrestrial rabies in the United States, NWRC scientists are studying the behavior, ecology, movement, and populations of raccoons and other wildlife hosts. They also are evaluating methods and techniques for vaccinating wildlife against rabies to decrease the spread of the disease in the wild.

Applying Science & Expertise to Wildlife Challenges

Testing New Rabies Vaccine Bait. — NWRC researchers are exploring a new oral rabies vaccine (ORV) product called ONRAB for use with raccoons and skunks. The current registered ORV product, RABORAL V-RG, has been successful at halting the westward spread of raccoon rabies, but the vaccination rate with this product may not be sufficient for the purpose of eliminating raccoon rabies. The new ONRAB bait product is showing promise at improving vaccination rates. A multiyear field trial in New Hampshire, New York, and Vermont resulted in the highest vaccination rates observed in raccoons after ORV treatments. On average, raccoons showed a vaccination rate near 70 percent—a level high enough to eliminate raccoon rabies across broad landscapes. In 2016, NWRC presented the field trial results to an interdisciplinary panel of rabies and wildlife experts, who used the data in formal recommendations to the WS National Rabies Management Program (NRMP) on a comprehensive 30-year strategy to eliminate raccoon rabies in the United States. NWRC also reported the ONRAB field trial results to the USDA Center for Veterinary Biologics; the information helped support a formal product review and potential product registration by industry. If registered, this new vaccine will offer an added tool in NRMP's efforts to eliminate the raccoon strain of rabies.

Estimating Mongoose Densities for Rabies Management. — The small Indian mongoose *(Herpestes auropunctatus)* is an invasive species that is a reservoir for rabies in Puerto Rico, accounting for more than 70 percent of the reported rabies cases on the island. An average of 280 Puerto Ricans are bitten each year by mongooses. Currently, no rabies vaccination program for mongooses exists on the island, and the vaccination of pets and domestic animals is limited. To help in the design of an ORV program on Puerto Rico for mongooses, NWRC researchers collected data on mongoose population dynamics, distribution, and density within two different ecosystems on the island—Cabo Rojo (Cabo Rojo) National Wildlife Refuge, made up of forest-scrub and grasslands; and El Yunque (El Yunque) National Forest, a subtropical rainforest. NWRC researchers trapped mongooses in both areas and then estimated their density using four different methods. The density estimation methods included: (1) a mongoose density index (MDI) adapted from the NRMP raccoon density index, (2) capture-mark-recapture, (3) spatially explicit capture-recapture, and (4) examining spatial distribution of mongooses within the study plots. The MDI method gave the lowest density estimates. It also showed a seasonal difference with greater densities of mongoose

during the wet season (55 mongooses per km^2) than the dry season (34 mongooses per km^2) at Cabo Rojo. At El Yunque, MDI detected 49 and 33 mongooses per km^2 in the wet and dry seasons, respectively. Researchers concluded the MDI estimation model can be used to inform bait distribution strategies and maximize ORV bait uptake by mongooses.

Rabies and Vampire Bats. — The common vampire bat feeds on the blood of livestock and other wildlife in Latin America. They also sometimes bite and feed on human blood and are currently the most important reservoir and vector of rabies to cattle and people in Latin America. Recently, vampire bats have been documented within 35 miles of the Texas border. This has caused concern and speculation about their potential movement to areas within the U.S. due to rising global temperatures. To better understand the likelihood of such movement, NWRC partnered with the U.S. Geological Survey to analyze and map the possible distribution of vampire bats under various future climate scenarios. Because there are relatively high numbers of cattle and other livestock in northeastern Mexico and southern Texas, wildlife managers and ranchers are concerned that vampire bats could survive in these areas and spread disease. This could have serious economic impacts to livestock producers since vampire bat bites are known to weaken cattle, reduce milk production, and cause secondary infections and sometimes death, especially if cattle contract rabies. Using more than 7,000 reports of vampire bats in northern Mexico and 5 modeling approaches, researchers mapped the species' potential distribution along the U.S.-Mexico border through the year 2070. The analysis suggests it is possible that vampire bats could expand their range into the U.S.—most likely into the southern tip of Texas and Florida. However, their range may be limited by winter temperatures. Researchers suggest continued monitoring for vampire bats along the Gulf coastal plains and southern Texas plains in the coming decades. Learning more about the potential northward spread of vampire bats gives disease specialists, health officials, wildlife managers, and livestock producers valuable information in the fight against rabies.

High Cost of Canine Rabies. — The World Health Organization estimates that, on average, about 60,000 people die of rabies each year, and 99 percent of these deaths are attributable to canine rabies in Asia and Africa. To provide a more complete assessment of canine rabies' global impact, NWRC economists extended current economic estimates to include the cost of human death risk. Human death risk is quantified by how much people are willing to pay to reduce their chances of dying or, conversely, how much people must be paid to tolerate increased risk. Researchers also accounted for both direct and indirect costs of rabies post-exposure prophylaxis, dog vaccination and control, rabies diagnostic testing, and cattle deaths. Using computer simulation models, they estimated the global burden of canine rabies to be about $124 billion per year. The results also highlighted important regional differences. Researchers found that the global burden from canine rabies falls most heavily on Asia, which accrues more than 80 percent of the nonhuman death costs. Africa, on the other hand, accounts for only 3 percent of nonhuman death costs but 45 percent of human deaths. This study illustrates the potential benefits of canine rabies elimination and provides an important benchmark for comparing rabies elimination campaign costs.

I**mproving Vaccine Technology. —** In December 2015, the U.S. Patent and Trademark Office issued a joint patent ("Adjuvanted Rabies Vaccine with Improved Viscosity Profile" [US 9,216,213]) to NWRC researchers and their Merial Ltd. cooperators for a new technology to improve immune responses in raccoons to rabies vaccines. This technology uses two benign compounds, chitosan and N,N,N trimethylated chitosan (TMC), to enhance the body's immune response to the RABORAL V-RG oral rabies vaccine. The compounds thicken the vaccine, increasing the amount of oral contact the raccoons have with the vaccine. The RABORAL V-RG vaccine is delivered as a liquid in a plastic sachet. While 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 sometimes hold the vaccine sachet on the ground and bite only small portions at a time, allowing the open sachet to leak. Chitosan is deacetylated chitin, a compound found naturally in crustaceans, insects, and mushrooms. When chitin is converted to chitosan and added to a vaccine, it improves the transport and absorption of the vaccine. In NWRC studies, adding TMC to existing RABORAL V-RG bait allowed raccoons to consume baits more easily and without leakage, and it did not interfere with the vaccine-induced immunity. NWRC is now seeking licensing partners for this new technology.

Selected Publications:

Anderson, A. and S.A. Shwiff. 2015. The cost of canine rabies on four continents. Transboundary and Emerging Diseases 62:446-452. doi: 10.1111/tbed.12168

Berentsen, A.R., S.R. Johnson, A.T. Gilbert, and K.C. VerCauteren. 2015. Exposure to rabies in small Indian mongooses (Herpestes auropunctatus) from two regions in Puerto Rico. Journal of Wildlife Diseases 51(4):896-900. doi:10.7589/2015-01-016

Johnson, S.R., N.J. Crider, G.A. Weyer, R.D. Tosh, and K.C. VerCauteren. 2016. Bait development for oral delivery of pharmaceuticals to raccoons and skunks. Journal of Wildlife Diseases 52(4):893-901. doi: 10.7589/2015-12-322

Johnson, S.R., A.R. Berentsen, C. Ellis, A. Davis, and K.C. Vercauteren. 2016. Estimates of small Indian mongoose densities: Implications for rabies management. The Journal of Wildlife Management 80(1):37-47. doi: 10.1002/jwmg.998

Theimer, T.C., A.C. Dyer, B.W. Keeley, A.T. Gilbert, and D.L. Bergman. 2017. Ecological potential for rabies virus transmission via scavenging of dead bats by mesocarnivores. Journal of Wildlife Diseases 53(2):382-385. doi:10.7589/2016-09-203

Major Research Accomplishments:

- WS evaluations of a new oral rabies vaccine (ORV) product called ONRAB resulted in the highest vaccination rates observed in raccoons. On average, raccoons showed a vaccination rate near 70 percent—a level high enough to eliminate raccoon rabies across broad landscapes.

- WS researchers collected data on mongoose population dynamics, distribution, and density in Puerto Rico to aid in the design of an ORV program on the island for mongooses.

- WS geneticists and partners analyzed and mapped the possible distribution of vampire bats in the southern United States under various future climate scenarios.

- Using computer simulation models, WS economists estimated the global burden of canine rabies to be about $124 billion per year.

- The U.S. Patent and Trademark Office issued a joint patent to WS researchers and their Merial Ltd. cooperators for a new technology to enhance immune responses in raccoons to rabies vaccines.