National Wildlife Research Center Scientists Use Chemistry to Resolve Wildlife Damage

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

NWRC scientists investigate the role of chemicals on animal behavior, such as foraging preferences, locating food and mates, and flavor aversion. Through a basic understanding of chemosensory science, NWRC research develops new or improves existing wildlife damage management tools, such as diagnostic methods for detecting diseases in wildlife, and novel baits, lures and repellents.

The NWRC Philadelphia, PA, field station is located at the Monell Chemical Senses Center. Monell is the world’s only non-profit scientific institute dedicated to basic research on taste and smell. It provides access to specialized research opportunities focused on the development of nonlethal wildlife repellents and attractants. Chemical ecology research involving olfactory, taste, and chemoreception senses is emphasized.

Applying Science and Expertise to Wildlife Challenges

Chemosensory Aspects of Repellency. — Taste, smell, sight, and touch permit herbivores to detect the chemosensory attributes of foods. These sensory cues, as well as an animal’s personal experiences, parental guidance and instinct, influence their foraging behaviors. Experiments by NWRC scientists showed that persistent avoidance of repellent-treated foods results only when a toxin is paired with the flavor of the food or repellent formulation. Furthermore, protein-based repellents (such as protein hydrolysates) reduced food consumption by herbivores, but not omnivores. Because they are plant eaters, herbivores likely experience conflicting chemosensory information when exposed to protein hydrolysates. Researchers conclude that effective herbivore repellent formulations must be applied directly to the food; and 2) have physiological or evolutionary consequences for the herbivore.

Avian Influenza Detection from Fecal Odors. — Many diseases cause a change in body odors. NWRC scientists and partners at the Monell Chemical Senses Center and Colorado State University studied changes of fecal odors in mallards infected with the avian influenza (AI) virus. Laboratory mice were trained to discriminate between feces from AI-infected and uninfected ducks, indicating a change in odor. Chemical analysis then found the volatiles (compounds that emit unique odors or emission patterns) associated with the odor changes to be acetoin and 1-octen-3-ol. These compounds have also been identified as potential biomarkers for diagnosing gastrointestinal diseases in humans. Researchers hypothesize that metabolites resulting from viral infection interact with bacteria in the gastrointestinal system of ducks to produce “odor signatures” indicating the presence of the AI virus. Ongoing research is focused on whether odor changes can be used for surveillance of AI in waterfowl. In particular, researchers are interested in whether the odor change is specific to the AI pathogen or if it is merely a general response to a variety of pathogens normally found in birds.

Training a Ferrets as a Disease Biosensor. — Recent avian influenza (AI) infection outbreaks have resulted in global biosecurity and economic concerns. In previous NWRC studies, trained mice correctly discriminated the health status of individual ducks on the basis of fecal odors when feces from AI post-infection periods were paired with feces from AI pre-infection periods. More recently, NWRC scientists and colleagues at Monell trained domesticated male ferrets (Mustela putorius furo) to respond by scratching/pawing at the ground when detecting acetoin (a fecal compound previously determined to be related to AI infection) in presented test samples. Ferrets rapidly generalized this learned response to the odor of feces from AI-infected mallards. These results suggest that a trained mammalian biosensor could be used in an AI surveillance program, resulting in significant savings over current laboratory testing methods.

Adapting Wildlife Research for Studies of Human Health. — The chemical analysis paradigm involving the use of volatile metabolites to detect disease lends itself to new discoveries in human
health research. In a study with Children's Hospital of Philadelphia (CHOP), NWRC and Monell researchers found that volatile metabolites were specifically altered by brain injury in a manner differing from general inflammation. Thus, monitoring changes in the volatile metabolome may be a useful for the rapid diagnosis of brain trauma and recovery. Additionally, researchers collaborating with Case Western Reserve University discovered differences in urinary volatiles between healthy mice and mice with human mutations of an Alzheimer's disease gene. These findings in animal models show that mutant gene expressions cause identifiable urinary odors, which if uncovered in clinical Alzheimer's patients, may serve as additional biomarkers for the disease.

New Bait for Brown Treessnakes. — A native of Australia, Papua New Guinea, and the Solomon Islands, the invasive brown treesnake threatens the economy and ecology of Guam and is currently the subject of a cooperative program to control its population and prevent its spread throughout the Pacific Rim. For many years, dead neonatal mice have been the gold standard lure for baiting invasive brown treesnakes on Guam. However, finding, keeping and using mice can be costly and messy. Dead mouse bait also decomposes quickly in the tropics, rendering it unacceptable to snakes. Recently, NWRC researchers tested a new brown treesnake bait made of processed meat and an artificial mouse fat mixture. Results showed the new bait was eaten by snakes at rates similar to the current dead mouse bait. It also remained viable and lasted longer under field conditions. Researchers are continuing to streamline the manufacturing process of the new bait. Current estimates indicate each new bait could potentially cost about 50¢ less than the current mouse bait, improving the cost-effectiveness of brown treesnake control efforts. 

Brown Treessnake Pheromones. — Pheromone-based technologies are sometimes used as attractants to help control invasive species. Pheromones are chemicals produced and released into the environment by an animal that affect the behavior or physiology of others of its species. Brown treesnakes are an invasive species on Guam. The female snakes emit “chemical trails” by releasing pheromones through their skin. These trails stimulate and aid in reproduction by helping males find receptive females. NWRC and James Madison University researchers revealed that sex identity in brown treesnakes can be determined by the ratio of specific skin lipids or pheromones (ketomonoenes to ketodienes). Researchers also discovered that skin lipid ratios were influenced by changes in the snakes’ sex hormones. These findings will aid in the development of pheromone-based tools for brown treesnake management.

Selected Publications:


Major Research Accomplishments:

- WS repellent research concludes that effective herbivore repellent formulations must be applied directly to the food; and 2) have physiological or evolutionary consequences for the herbivore.

- WS research identified unique “odor signatures” associated with the feces of mallards infected with avian influenza virus. Ongoing research with domestic ferrets has demonstrated that trained animals can be used for surveillance of the virus in waterfowl.

- The chemical analysis paradigm developed by WS researchers to address wildlife disease detection and surveillance led to new discoveries in human health research regarding biomarkers of Alzheimer's disease and traumatic brain injury.

- WS researchers developed and tested a new brown treesnake bait made of processed meat and an artificial mouse fat mixture. Results showed the bait was eaten by snakes at rates similar to the current bait and lasted longer under field conditions.

- WS and James Madison University researchers discovered that sex identity and pheromones released by a brown treesnake are determined by the ratio of specific skin lipids in the snake. Findings will aid in the development of pheromone-based tools for brown treesnake management.