United States Department of Agriculture

Animal and Plant Health Inspection Service

Wildlife Services

FY 2004

Integrated Research and Management Strategies for Brown Treesnakes on Guam

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National Wildlife Research Center Scientists Examine Methods for Controlling and Managing Brown Treesnakes on Guam

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 acceptable methods, tools, and techniques.

Since 1995, NWRC has received funding from the U.S. Department of Defense Legacy Resource Management Program, the U.S. Department of the Interior (DOI) U.S. Geological Survey, and the DOI Office of Insular Affairs to research methods to manage and control the spread of brown treesnakes on Guam and other islands.

Management of the brown treesnake, through the development of integrated strategies, is aimed at preventing its dispersal through cargo; containing incoming snakes at destinations; reclaiming areas on Guam for reintroduction of native wildlife; protecting endangered species and other wildlife; improving public health; and protecting power stations and other sensitive locations from intrusion. To achieve these aims, brown treesnake research efforts at NWRC encompass the development of repellents, attractants, toxicants, fumigants, reproductive inhibitors, and improved trapping methods.

Groups Affected by This Problem:

- Citizens of Guam
- Guam Power Authority
- Guam Department of Agriculture
- U.S. Navy
- U.S. Air Force
- U.S. Fish and Wildlife Service
- U.S. Department of the Interior

Major Cooperators:

- Guam Wildlife Services
- Guam Department of Agriculture
- U.S. Navy
- U.S. Air Force
- U.S. Department of the Interior
- Center for Reproduction of Endangered Species (CRES)

Applying Science and Expertise to Wildlife Challenges

Trapping—NWRC scientists work closely with Guam Wildlife Services biologists to develop traps, trap placement strategies, and snake-trap attractants. Trapping takes place throughout the island around forested plots, as well as along fences, buildings, and other sites. Trapping is especially important around airports, cargo areas, and electrical power substations. Since 1993 more than 50,000 snakes have been trapped and removed from Guam. Trapping is central to the control activities carried out on Guam, yet it is only one component of an integrated control program using multiple methods and employing sequential, strategic approaches for snake removal over large areas.

Fumigants and Toxicants—A potential means for deterring the spread of brown treesnakes from Guam is to apply a fumigant to outbound cargo. Products already registered with the U.S. Environmental Protection Agency (USEPA) for fumigation were tested by NWRC scientists. Methyl bromide was found to be highly effective against the snakes. However, when methyl bromide was also found to be an ozone reducer, attention shifted to two other fumigants: sulfuryl fluoride and magnesium phosphide. Methyl bromide is registered with the USEPA for use on brown treesnakes and registrations for sulfuryl fluoride and magnesium phosphide are pending.

NWRC investigated over-the-counter analgesics and found that acetaminophen was highly toxic to brown treesnakes. Acetaminophen inserted into dead mice proved to be a successful bait delivery system. The mice/acetaminophen method of control is registered with USEPA.

Lures and Attractants—Artificial attractants could greatly improve the costs and logistics for delivering toxicants to brown treesnakes by enticing snakes to consume toxic baits or by luring them into a trap. Similarly, attractants could also be used in baits to deliver a contraceptive substance.

NWRC scientists successfully characterized the odor of dead and decomposing mice for use in an artificial attractant. NWRC scientists have also identified artificial chemicals such as methyl-1-butanethiol, butyric acid ethyl ester, and dimethyl disulfide as mildly attractive to snakes. NWRC's next step is to develop a suitable matrix in which this "mouse essence" can be embedded. So far, compounds as diverse as PVC, tofu, plaster-of-paris, and gelatin have shown promise as mildly effective encapsulating mediums.

Reproductive Inhibition—NWRC scientists are studying snake reproduction in hopes of developing reproductive inhibitors. Initial work has focused on gaining a better understanding of brown treesnake reproductive biology. Studies have showed that only about 14% of the female brown treesnakes are in reproductive condition at any given time, and they apparently breed throughout the year. All male brown treesnakes, on the other hand, are capable of being reproductively active throughout the year. Scientists are investigating two types of reproductive inhibitors. One is a gonadotropin-releasing hormone vaccine which, if effective, would inhibit production of steroid hormones. The other focuses on a class of chemicals known as alkylating agents. Initial tests show that some of these agents shut down reproduction in male snakes.

Repellents—Repellents or irritants are important for driving brown treesnakes from areas where they can stowaway in cargo containers and transport vessels. NWRC scientists have been looking at natural products as repellents. These compounds require minimal support data because they are already considered safe. Recent compounds tested, such as cinnamon oil, clove oil, and eugenol are now available for use on brown treesnakes. These repellents could be applied to cargo before leaving Guam, thus preventing snakes from spreading to other locations.

Major Research Accomplishments:

- WS developed data for the registration of methyl bromide (US EPA Reg. No. 5785-41) as a cargo fumigant for brown treesnakes. Registrations for sulfuryl fluoride and magnesium phosphide as cargo fumigants are pending.
- WS conducted attractant/lure research showing that the odor from dead mice is equally as effective as live mice for capturing snakes in traps and that snakes consume dead mouse carrion baits. Dead mice are now being used as baits for toxicants and chemosterilants.
- WS identified skin bacteria from young dead mice as being critical for the production of the decomposition odors that are attractive to brown treesnakes. Using these data, a more economical synthetic bait matrix using mouse bacteria may be feasible.
- WS conducted field evaluations and provided data for the registration of acetaminophen (US EPA Reg. No. 56228-34) as a brown treesnake oral toxicant in dead mouse baits for both bait station and aerial delivery applications.
- WS showed that cinnamon oil, clove oil, and eugenol are effective repellents for driving brown treesnakes out of enclosed spaces.
- WS conducted an array of field and laboratory studies to characterize the reproductive biology of the brown treesnake. This knowledge is being used to guide development of reproductive inhibition as a control tool. Field studies have shown there is no breeding season: females reproduce sporadically throughout the year and males are constantly reproductive. Laboratory studies have shown that a period of slightly reduced environmental temperatures elicits ovarian growth in females, the drop in temperature being the apparent trigger. Females are attractive and receptive to males just prior to ovulation, and females that go unmated do not ovulate: all preovulatory follicles are resorbed. In contrast to many other snake species, females do not possess sperm storage structures in the oviducts. Males commonly engage in combat for reproductive females.
- WS tested a gonadotropin-releasing hormone (GnRH) vaccine on the African house snake, a surrogate species, as well as the brown treesnake. Both species produced high and sustained (1 yr + in African house snake) blood levels of antibodies against GnRH. Studies are underway to determine whether the vaccine inhibits reproduction.
- WS tested various alkylating agents for their potential to inhibit reproduction. Three agents (thiotepa, busulfan, chlorambucil) effectively inhibited testicular function in males. The effects of these agents on ovarian growth in females are currently under evaluation.
- WS formed more than 10 effective partnerships/collaborations with other Federal, state, territories, and academic agencies that have major interests in the management, control, and eradication of brown treesnakes on Guam and the Commonwealth of the Northern Mariana Islands.
- To date, WS has published more than 55 brown treesnake papers related to the behavior, trapping strategies, toxicity of oral and dermal toxicants, responses to attractants/lures and repellents, bait delivery by bait stations and aerial application, and reproductive physiology; and have made more than 35 presentations at scientific and stakeholder meetings.

Selected Publications:

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- Mathies, T.; Franklin, E. A.; Miller, L. A. 2004. Proximate cues for ovarian recrudescence and ovulation in the brown treesnake (Boiga irregularis) under laboratory conditions. Herpetological Review 35(1):46-49.
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- Mathies, T.; Miller, L. A. 2003. Cool temperatures elicit reproduction in a biologically invasive predator, the brown treesnake (Boiga irregularis). Zoo Biology 22:227-238.
- Clark, L.; Shivik, J. 2002. Aerosolized essential oils and individual natural product compounds in brown treesnake repellents. Pest Management Science 58:775-783.
- Engeman, R.M.; Vice, D. S.; York, D.; Gruver, K. S. 2002. Sustained evaluation of the effectiveness of detector dogs for locating brown tree snakes in cargo outbound from Guam. International Biodeterioration & Biodegradation 49:101-106.
- Johnston, J.J.; Savarie, P. J.; Primus, T. M.; Eisemann, J. D.; Hurley, J. C.; Kohler, D. J. 2002. Risk assessment of an acetaminophen baiting program for chemical control of brown tree snakes on Guam: evaluation of baits, snake residues, and potential primary and secondary hazards. Environmental Science & Technology 36:3827-3833.
- Shivik, J.A.; Savarie, P. J.; Clark, L. 2002. Aerial delivery of baits to brown treesnakes. Wildlife Society Bulletin 30:1062-1067.
- Jojola-Elverum, S. M.; Shivik, J. A.; Clark, L. 2001. Importance of bacterial decomposition and carrion substrate to foraging brown treesnakes. Journal of Chemical Ecology 27(7):1315-1331.
- Savarie, P.J.; Shivik, J. A.; White, G. C.; Hurley, J. C; Clark, L. 2001. Use of acetaminophen for large-scale control of brown treesnakes. Journal of Wildlife Management 65(2):356-365.