Brown Treesnake Working Group
Technical Meeting

Agenda & Abstracts

17, 18 & 19 April 2007

Pacific Island Club
Tumon Bay, Guam

Tuesday, 17 April 2007

9:00 AM Morning Session moderator – Earl Campbell, USFWS

Welcome and opening remarks.
Review agenda, logistics, announcements, housekeeping.
Introduction of participants.

Brown Treesnake - Biology, control, agency roles, and budgets.
Earl Campbell.
DOI - U.S. Fish and Wildlife Service.

The Cocos Island Guam rail project: ko'ko for Cocos.
Diane Vice.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

~ 10:30 Break

Brown Treesnake work in the CNMI: An update.
Nate Hawley.
USFWS / CNMI - Division of Forestry and Wildlife.

From television and newspapers to viral videos and toe-tapping jingles.
Christy Martin.
Coordinating Group on Alien Pest Species, Honolulu, Hawaii.

The National Wildlife Research Center - An agency overview of Brown Treesnake (BTS) research.
Kathleen A. Fagerstone, Peter J. Savarie, and Tom Mathies.
USDA – APHIS – Wildlife Services - National Wildlife Research Center,
Fort Collins, CO.

12:00 - 1:00 Lunch

1:00 – Afternoon Session moderator – Nate Hawley, USFWS / CNMI - DFW

The Rapid Response Team: Past, present, future.
James Stanford and Rebecca Stafford.
USGS / Colorado State University Brown Treesnake Project, Fort Collins, CO / Guam.

Working dogs: Conservation and resource management uses in New Zealand.
Kristin Winford.
USGS / Colorado State University Brown Treesnake Project, Fort Collins, CO / Guam.

Canine Programs: A review.

This session will have 15 – 20 minute overview presentations from the following programs. Each of the following canine programs has prepared presentations that will include a discussion of a series of questions all canine programs have agreed upon.

The programs are:

1) USDA – APHIS – Wildlife Services
2) Hawaii Department of Agriculture
3) CNMI Department of Fish and Wildlife
4) USGS Rapid Response Team
5) Navy Military Working Dog Program – a non-BTS program for comparison

Moderated questions from the audience to presenters will follow. It is hoped that canine program representatives will have opportunities to meet separately following this session.

~ 2:30 Break will occur during the canine program session.

3:30 to 4:00 Adjourn

4:30 – 8:00 Canine Training & Inspection Procedures Discussion.
Pacific Islands Club.
Contact Jason Gibbons, USDA – APHIS Wildlife Services.

5:00 – 8:00 Public Scoping Meetings for Marine and Army relocation to Guam from Okinawa.
Yona Community Center.

7:30 – 9:30 potential snake search via vehicle and spot light
meet in the PIC Lobby at 7:30 PM
details will be announced during meeting.

Wednesday, April 18

9:00 AM - Morning Session Moderator – Mark Defley, U.S. Navy

Evaluation of a long-term landscape-level control program to reduce BTS populations
Will Pitt, Robert T. Sugihara and Dan Vice.
USDA – APHIS – WS - National Wildlife Research Center, Ft. Collins, CO (WP),
USDA – APHIS – WS - National Wildlife Research Center, Hilo, HI, and
USDA – APHIS – Wildlife Services Operations, Guam (DV).

An operational assessment of toxicant and trap use and their demographic effects on the Brown Treesnake (Boiga irregularis).
Craig S. Clark, Daniel S. Vice, Peter J. Savarie and Marc A. Hall.
USDA – APHIS – Wildlife Services – Guam (CSC, DSV, MAH).
USDA – APHIS – Wildlife Services - National Wildlife Research Center,
Fort Collins, CO (PJS).

The Closed Population project: precise monitoring of a Brown Treesnake population without emigration or immigration allows precise inference about the effectiveness of control tools.
Gordon H. Rodda, Julie Savidge, Michelle T. Christy, Claudine L. Tyrrell and Amy Yackel-Adams.
USGS (GR) / Colorado State University Brown Treesnake Project, Fort Collins, CO / Guam (JS, MC, CT,AY-A).

Vital rates of Brown Treesnakes (Boiga irregularis) from a geographically closed population on Guam.
Gordon H. Rodda, Robert N. Reed, Julie A. Savidge, Michelle T. Christy, Amy Yackel-Adams, and Claudine L. Tyrrell.
USGS Fort Collins Science Center, Fort Collins, CO / Guam.

~ 10:30 Break

Captive breeding of Guam's endangered species.
Caplan Anderson.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

Mariana crow recovery on Guam.
Jeff Quitigua.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

Guam National Wildlife Refuge: An introduction.
Chris Bandy.
Guam National Wildlife Refuge.

A CWCS resource protection partnership: watershed protection, habitat restoration and endangered species recovery
David T. Limtiaco,
Guam Department of Agriculture's Division of Forest and Soil Resources

Agency Updates from other Guam-based natural resource management agencies.

12:00 – 1:00 Lunch

1:00 – Afternoon Session Moderator – Dan Vice, USDA – APHIS - WS

Climate matching as a tool for predicting potential spread of Brown Treesnakes.
Gordon H. Rodda and Robert N. Reed.
USGS Fort Collins Science Center, Fort Collins, CO.

Forecasting the risk of Brown Treesnake dispersal from Guam: a mixed transport establishment model.
Gad Perry and Dan Vice.
Texas Tech University, Lubbock, Texas (GP),
USDA – APHIS – Wildlife Services, Guam (DV).

Can temperature be used as a tool for limiting Brown Treesnake (Boiga irregularis) invasion via transit pathways?
Michelle T. Christy, Richard O. Bischof, Gordon H. Rodda, and Julie A. Savidge.
USGS (GR) / Colorado State University Brown Treesnake Project (MC and JS), Fort Collins, CO / Guam; and Norwegian University of Life Sciences, Norway (RB).

Inspection documentation and its application to monitoring the export cargo flow through Guam's transportation network.
Jason C. Gibbons, Daniel. S. Vice, Mark. A. Hall, Joseph M. Sablan.
USDA – APHIS – Wildlife Services Operations, Guam.

~ 2:30 Break

Delaying the catastrophic arrival of the Brown Treesnake to Hawaii.
Kimberly Burnett, James Roumasset, and Yacov Tsur.
University of Hawaii at Manoa (KB, JR), Hebrew University of Jerusalem (YT).

Spatial economic analysis of early detection and rapid response strategies for the Brown Treesnake.
Brooks Kaiser and Kimberly Burnett.
Gettysburg College (BK), University of Hawaii at Manoa (KB).

Preventing reptile and amphibian invasions: Using pathway analysis to develop risk assessment procedures.
Fred Kraus.
B. P Bishop Museum, Honolulu, Hawaii.

3:30 – 4:00 Adjourn

5:00 – 8:00 PM **Dededo Senior Citizens Center.**
Public Scoping Meetings for Marine and Army relocation to Guam from Okinawa

7:30 – 9:30 PM **Snake searching on foot**
meet in the PIC Lobby at 7:30 PM
Lights, snake bags, and transportation provided
Participants should wear closed-toed shoes and bring water

Thursday, April 19, 2007

9:00 AM – Morning Session Moderator – Bob Reed, USGS - FORT

Listen Up Guam!: Early detection and monitoring of an invasive species.
David Gee.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

Introduced rodent and shrew densities and distributions in the Mariana Islands: Implications for Brown Treesnake control and management.
Andrew S. Wiewel, Gordon H. Rodda, and Amy A. Yackel-Adams.
USGS / Colorado State University Brown Treesnake Project, Fort Collins, CO / Guam.

Cocos Island Rodent Eradication.
Dana. T. Lujan, Will Pitt, and Dan Vice.
USDA – APHIS – Wildlife Services Operations, Guam (DTL, DV) and USDA – APHIS – WS - National Wildlife Research Center, Hilo, HI (WP).

Experimental manipulation of food in the wild: How rodent prey suppression increases movements in the Brown Treesnake (Boiga irregularis) on Guam.
Michelle T. Christy, Julie A. Savidge, Amy A. Yackel Adams, and Gordon H. Rodda.
USGS / Colorado State University Brown Treesnake Project, Fort Collins, CO / Guam.

~ 10:30 Break

Spotting cryptic animals in the dark: What light properties should a good headlamp have?
Björn Lardner, Julie A. Savidge, and Gordon H. Rodda.
USGS / Colorado State University Brown Treesnake Project, Fort Collins, CO / Guam.

Factors affecting visual detections of a geographically closed population of Brown Treesnakes (Boiga irregularis) on Guam.
Michelle T. Christy, Amy A. Yackel Adams, Gordon H. Rodda, Julie A. Savidge.
USGS / Colorado State University Brown Treesnake Project, Fort Collins, CO / Guam.

Male behavioral responses to female Brown Treesnake skin secretions.
Tom Mathies, Julie A. Savidge, and Lowell M, Miller.
USDA – APHIS – WS - National Wildlife Research Center, Ft. Collins, CO (TM, LM); and Department of Fish, Wildlife, and Conservation Biology, Colorado State University, Fort Collins, CO (JS).

Field evaluations of unadulterated, freeze-dried, and dehydrated dead neonatal mice as baits and live trap lures for Brown Treesnakes.
Peter J. Savarie, Tom C. Mathies, Marc A. Hall, Kenneth L. Tope, and Kathleen A. Fagerstone,
USDA – APHIS – WS - National Wildlife Research Center, Ft. Collins, CO (PJS, TCM, KLT, KAS); and USDA – APHIS - Wildlife Services, Guam (MAH).

12:00 - 1:00 Lunch

1:00 – Afternoon Session Moderator – Mindy Wilkinson, Hawaii DLNR - DoFW

Field evaluations: paper products for aerial delivery of baits and mechanical mice as live trap lures for Brown Treesnakes.
Peter J. Savarie, Tom C. Mathies, Kenneth L. Tope, and Kathleen A. Fagerstone.

Cabras Island: The operational use of an oral toxicant for Brown Treesnakes.
Marc A Hall.
USDA – APHIS – Wildlife Services – Guam.

USDA – APHIS – Wildlife Services Programmatic Update for Guam.
Dan Vice,
USDA – APHIS – Wildlife Services, Guam.
USDA – APHIS – Wildlife Services - National Wildlife Research Center, Fort Collins, CO.

Hawaii Update: Snakes and frogs.
Domingo Cravalho, Mindy Wilkinson, and Scott Williamson.
Hawaii Department of Agriculture – Plant Quarantine Branch (DC) and Hawaii Department of Land and Natural Resources – Division of Forestry and Wildlife (MW, SW).

~ 2:30 Break

Saipan snake search activities.
Nate Hawley and James Stanford.
US Fish and Wildlife Service / CNMI DFW, and USGS Brown Treesnake Rapid Response Team, Guam.

A Pacific snake sighting database: Updates and improvements.
Sky Harrison.
USGS – Pacific Basin Internet Node, Maui, Hawaii.

Pacific Invasive Species Learning Network.
Jill Key.
Pacific Invasives Learning Network (PILN),
South Pacific Regional Environmental Program.
Apia, Samoa.

Formation and progress of the Micronesia Regional Invasive Species Council (RISC).
David Gee.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

4:00 Adjourn

4:15 Brief meeting for Brown Treesnake Working Group Agency Representatives.

Abstracts

Captive breeding of Guam's endangered species.
Caplan Anderson.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

During the mid 1980s the few remaining sihek (*Halcyon c. cinnamomina*) and ko'ko' (*Gallirallus owstonii*) were collected from the wild on Guam for the establishment of captive breeding populations. Until recently, all existing sihek were located at various mainland zoos and their population had remained around 55 birds in spite of aggressive breeding efforts. Four years ago 4.1 sihek were sent back to Guam in an attempt to see if their native climate and diet could increase productivity and survivorship. By the end of the second year Guam's sihek breeding program produced 2.1 healthy chicks, including one parent-reared female. A major setback occurred with the loss of the only adult female; thus, breeding is currently on hold until additional females arrive from the mainland. The ko'ko' breeding facility on Guam has been very successful in the past 5 years, producing over 400 birds for release. Snake-free Rota remains the primary focus of release efforts. A new release site was established last year in the southern part of Rota in hopes of decreasing dispersal, starvation, and predation. On Guam partnerships with Guam Forestry and Soil Resources and Department of Defence may provide an avenue for the creation of future release sites for Guam rails. In an effort to increase public awareness of Guam's endangered species, imprinted or disabled ko'ko' have been placed as "ambassadors" into local institutions for display.

Delaying the Catastrophic Arrival of the Brown Treesnake to Hawaii.
Kimberly Burnett, James Roumasset, and Yacov Tsur.
University of Hawaii at Manoa (KB, JR), Hebrew University of Jerusalem (YT).

This paper develops a two-stage model for the optimal management of a potential invasive species. The arrival of an invasive species is modeled as an irreversible event with an uncertain arrival time, or catastrophe. We motivate the problem using the threat of the Brown Treesnake to Hawaii.

The model is solved in two stages, beginning with the second stage, or post-invasion, and solves for optimal management after the snake has invaded. In this stage of the model we assume that the population size is known, post arrival. The loss-minimizing paths of prevention and control are identified, resulting in a minimized present value penalty associated with the invasion. After calculating this penalty, we return to the pre-invasion stage of the model and solve for the level of prevention expenditures that will minimize the total value of the invasion, pre and post-invasion. Spending on prevention alters the probability of arrival. One can then solve for optimal prevention expenditures.

Using the exponential distribution to describe the probability of establishment, we find that prevention expenditures made before the invasion should remain constant at $4.8 million every year until invasion. Once invasion occurs, optimal management requires lower annual expenditures on prevention ($3.1 million) but requires $1.6 million to be

spent on removal annually to keep the population at a low steady state level. Minimum annualized losses associated with the BTS invasion are estimated at roughly $5.7 million.

Can temperature be used as a tool for limiting Brown Treesnake (*Boiga irregularis*) invasion via transit pathways?

Michelle T. Christy, Richard O. Bischof, Gordon H. Rodda, and Julie A. Savidge. USGS, Fort Collins Science Center (GR), Colorado State University, Fort Collins, CO (MC and JS); and Norwegian University of Life Sciences, Norway (RB).

The use of extreme temperatures is one of the few chemical residue-free techniques available for control of pest species, and has proven fast and effective in a variety of applications. However, little consideration has been given to its use for vertebrate pest management. Manipulating temperatures in confined spaces such as cargo holds and containers may be a useful tool in the reduction or elimination of stowaway species such as the Brown Treesnake (*Boiga irregularis*) that might otherwise be transported to new locations. The efficacy of thermal fumigation as a control tool is reliant upon first establishing the lethal tolerance limits of the most robust individuals and determining whether this falls within an operationally practical range for use in shipping containers, aircraft cargo holds and aircraft wheel wells. We tested *B. irregularis* at a variety of temperatures to determine the lethal tolerance limits for the species. We also investigated factors such as sex, size and exposure time, all of which may influence the ability of individuals to survive temperature extremes. Previously, we presented preliminary data on the effect of high temperatures on *B. irregularis* survival; here we also present the species' tolerance to cold temperatures. The lower lethal tolerance limit was more difficult to determine than the upper lethal tolerance limit, but we recorded 100% mortality at -5˚C within 24 hours. These results shed light on the possible application of thermal fumigation for snakes and other invasive ectotherms in transit. We will discuss these and other results in terms of relevance to *B. irregularis* management, with emphasis on the prevention of future invasion of snake-free islands.

Experimental manipulation of food in the wild: how rodent prey suppression increases movements in the Brown Treesnake (*Boiga irregularis*) on Guam.

Michelle T. Christy, Julie A. Savidge, Amy A. Yackel-Adams, Gordon H. Rodda. Colorado State University, Fort Collins, CO (MC and JS), and USGS, Fort Collins Science Center (AY and GR).

Animal movement is driven primarily by the distribution and density of critical resources such as food, shelter, and mates. Prey abundance and foraging play an important role in determining when, where, and why animals move. We studied the movement of the Brown Treesnake (*Boiga irregularis*) in rodent-abundant (control) and rodent-reduced (treatment) grassland habitats by radio-tracking 24 snakes across four 4-ha plots over a 40-day period. *B. irregularis* moved extensively during any given night, but these movements were not always reflected in the size of the activity area. Short-term (16-day) activity areas were large, ranging from 10 - 92 ha. Snakes associated with prey-depleted

environments had 40% larger activity areas, almost double the dispersal distance, and 30% greater movement rates than snakes on control plots. Most measures of movement did not differ between sexes but the body condition of the snake had a large effect on movement rate; irrespective of plot treatment, snakes with an above average condition index moved greater distances per hour than those with a below average condition index. Our study indicates that a relatively small rodent-reduction treatment area can influence snake dispersal, possibly as a function of disruption to foraging strategies. Rodenticide treatment may inadvertently facilitate the spread of snakes in incipient colonizations.

Factors affecting visual detections of a geographically closed population of Brown Treesnakes (*Boiga irregularis*) on Guam

Michelle T. Christy, Amy A. Yackel Adams, Gordon H. Rodda, Julie A. Savidge. Colorado State University, Fort Collins, CO (MC and JS), and USGS, Fort Collins Science Center (AY and GR).

Visual surveys are routinely used to determine the abundance or presence of a species. A commonly overlooked fact is that that not only species but also individuals can vary in their detectability. Failing to account for this variation will result in biased estimates of abundance and errors in judging a species' presence. Judging a species' presence is vital for eradication of incipient or residual populations. In an attempt to improve our understanding of the factors influencing Brown Treesnake (*Boiga irregularis*) detectability, we designed a visual capture-recapture study to estimate detection probability as a function of gender, size (snout vent length), condition index, trend of condition index, growth index, recent detection history, searcher team, and weather covariates (i.e., wind, gusts, moon, and rainfall). We enclosed a 5-ha semi-forested study area in northern Guam with a double bulge barrier to prevent immigration and emigration of *B. irregularis* from the site. During 109 visual searches along maintained transects, we obtained 654 visual detections of 117 individual snakes. Overall average detection probability was 0.058 (in a population of 100 *B. irregularis*, a searcher team of four would detect 5.8 snakes in 3.5 hours of night-time searching). The results supported sex-specific differences in detectability that were a function of size, with both small and large female snakes having lower detection probabilities than males. There was strong support for incorporating the recent detection history of a snake (prior 2 survey occasions) into the model structure. This resulted in roughly a doubling (0.08 and 0.05 increase) in detection probability for averaged-sized males and females, respectively, if they had been caught on the prior occasion. Body condition index effects were small and resulted in low condition (skinnier) snakes having estimated mean capture probabilities of only 0.002 greater than snakes with high body condition. On any given occasion, searchers with high *B. irregularis* detection rates increased detection probabilities almost two-fold over searchers with lower detection rates. Night surveys with strong gusts of wind and moonlight slightly decreased the probability of detecting snakes.

The National Wildlife Research Center—An agency overview of Brown Treesnake (BTS) research.

Kathleen A. Fagerstone, Peter J. Savarie, and Tom Mathies.
National Wildlife Research Center, Fort Collins, CO.

The National Wildlife Research Center has been developing Brown Treesnake (BTS) control tools since 1991. During FY06, research focused on six areas:

1) Development of Bait Matrices for Delivery of Acetaminophen to BTS: Unadulterated dead neonatal mice (uDNM) are the baits currently used, but they become difficult to handle after a short period in the field. Bait take of freeze-dried DNM (fdDNM) and dehydrated DNM (dDNM) were investigated.
2) Live Trap Capture Evaluations: It would be advantageous to have an alternative for live mice that would be effective as live trap lure. Dead neonatal mice, freeze-dried DNM, and dehydrated DNM were tested against live mice as lures for traps.
3) Evaluation of Mechanical Mice for Use as Lures in Live Traps: Mechanized "mice" were tested for their ability to bring BTS to traps.
4) Development of Aerial Delivery Systems: NWRC continued to test aerial delivery systems for acetaminophen baits.
5) Development of a Pheromonal Attactant for BTS: Studies were undertaken to determine whether the scent from the skin of females is attractive to males and whether the response differs according to female reproductive condition.
6) The NWRC assisted Wildlife Services operations with an eradication program on Cabras Island to implement acetaminophen baits into ongoing BTS containment activities.

In FY06, NWRC received $60,000 from the Office of Insular Affairs (OIA) for development of lures, flotation materials, and alternative bait matrices for dead mice. Two proposals were funded by the Hawaii Invasive Species Council (HISC) for development of baits and attractant lures, and for development of the female sex pheromone as a male attractant. In FY07, NWRC is receiving $60,000 from the OIA and is attempting to obtain funding from the DOD Environmental Security Technology Certification Program (ESTCP) for testing large-scale aerial application of acetaminophen-treated baits for control of BTS. NWRC and Wildlife Services operations are also receiving funding from COMNAVMARIANAS to develop an automated system for delivery of acetaminophen-treated baits by aircraft, and develop BTS bait stations that are inaccessible to non-target species.

Listen Up Guam!: Early detection and monitoring of invasive species
David Gee.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources

Greenhouse frogs (*Eleutherodactylus planirostris*) were discovered in Upper Tumon, Guam in October 2003. Other species previously unknown on Guam were subsequently discovered or investigated, including *Rana guentheri* (barking frog), *Microhyla pulchra*, *Polypedates megacephalus*, *Fejervarya cancrivora*, *Fejervarya limnocharis*, and *E. coqui* (coqui frog). Of these, the latter is the only species not known to be present on Guam. Two specimens were recovered in February 2004, and none have been captured since. Surveys of plant nurseries and heavily landscaped properties (i.e. golf courses and resort hotels) and public reports of frog occurrences reveal spreading populations of greenhouse frogs and barking frogs. The Listen Up Guam! coqui frog awareness campaign is designed to alert residents of Guam to the damage associated with *E. coqui* in its introduced range. The central feature of the campaign is a hotline, 687-FROG, sponsored by GuamCell Communications. Radio and print advertisements, mass-mailings, and physical collateral distribution have been used to brand the campaign. Over 550 calls have been received since March 2005. No coqui frogs have been identified; calls identifying other species have been used to track movements and to intercept new arrivals including a Northwest salamander (*Ambystoma gracile*), a Pacific tree frog (*Pseudacris regilla*), and a brown anole (*Norops sagrei*).

Formation and progress of the Micronesia Regional Invasive Species Council (RISC).
David Gee.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

The Micronesia Regional Invasive Species Council (RISC) was formed in July 2004 by a cooperative agreement between the President of the Republic of Palau and the Governors of the Commonwealth of the Northern Mariana Islands, Guam, and Yap State (Federated States of Micronesia) at the Third Western Micronesian Chief Executives' Summit. The Council was created to facilitate information exchange and to coordinate projects regarding invasive species for all of Micronesia. The Council is comprised of two members, appointed by the Chief Executive of their State, from each member jurisdiction. The organization has met a total of nine times in three years and to date has: created, printed and distributed a calendar featuring invasive species from the region; acquired funding from the budgets of the Chief Executives; secured agreements from the executives to fund and hire invasive species coordinators for each Member State; completed and signed a charter endorsed by the sixth Chief Executives' Summit; drafted a regional five-year plan for invasive species management. This talk will be a brief history of the Council and its accomplishments, followed by a question-and-answer session intended to produce suggestions for future projects and goals.

Inspection Documentation and its Application to Monitoring the Export Cargo Flow Through Guam's Transportation Network

Jason C. Gibbons, Daniel S. Vice, Marc A. Hall, and Joseph M. Sablan
USDA/APHIS/Wildlife Services, Guam

The movement of outbound civilian and military cargo from Guam presents extensive opportunities for the dispersal of Brown Treesnakes from the island. To prevent such events, USDA, APHIS, Wildlife Services has implemented and manages a comprehensive snake containment program, which includes inspection of outbound materials using specially trained snake detector dogs. Between September 2004 and April 2006 to meet cooperator reporting requirements Wildlife Services developed, refined, and implemented numerous documentation and operational procedures for prioritizing Brown Treesnake inspections and recording inspected *and* un-inspected cargo. Simultaneously, Wildlife Services assisted the command of Andersen Air Force Base in the development of an operating instruction requiring 100% inspection of all outbound aircraft and related cargo, resulting in four snake detections that would have not otherwise occurred. The infrastructure or document needed to enact similar standards within the commercial sector does not exist. This paper summarizes Wildlife Services' documentation procedures and data collected between February 2006 and February 2007.

Cabras Island: The operational use of an oral toxicant for Brown Treesnakes.

Marc A Hall.
Wildlife Services Guam

Large scale control of the Brown Treesnake (Boiga irregularis; BTS) is limited by available methodologies. The operational use of oral toxicants (acetaminophen) may expand programmatic BTS control capabilities by reducing resource inputs and increasing the targeted snake population. An operational test project using toxicants was activated on Cabras Island, Guam, in September 2006. The island, approximately 150 acres in size and situated off the west coast of Guam, serves as the primary commercial port for the island. Cabras Island can be viewed as a microcosm of Guam and has the benefits of a manageable landscape, ease of access (established cooperators), and limited opportunity for incursion by BTS post-primary control. Control activities have been organized to start from the extreme western tip of the breakwater and are being implemented over three phases. Each phase involves saturating the targeted area with bait stations followed by a reduction (50%) as the project moves into the next area of maximum control. Phase one has been completed and lasted a period of 26 weeks. One thousand mice were distributed each week (two baiting periods/week) with an average weekly take rate of 4%, the total take for the duration of the first phase was $n = 1055$; phase two began on March 9, 2007. The most significant finding was the potential impact that non-targets appear to have on bait take numbers. Further program development will address logistical challenges, data management, and interpretation of bait take, to better refine operational use of this important control tool.

Dogs in the Woods: The complexity of a snake-detecting dog research program.
Ginger Haddock, Kristin Winford, Rebecca Stafford, James Stanford, Robert Reed, Gordon Rodda, and Julie Savidge.
USGS (GH, KW, RS, JS, RR, and GR), / Colorado State University (Julie Savidge)

The USGS initiated a detector dog program, known as Dogs in the Woods (DIW), in 2004. The DIW program is an experimental attempt to assess the feasibility and efficacy of using detector dogs to locate Brown Treesnake (BTS) in areas with low snake densities and complex natural and human manipulated habitats. Established tools for capturing BTS such as visual searching and trapping are less than ideal when snake densities are exceptionally low, or when snake prey densities are high; both of these situations may be expected when searching for newly-established incipient populations on islands other than Guam. The success of the USDA-WS detector dog program and numerous other detector dog programs around the globe were driving forces in developing the DIW program. The program continues to evolve and increase in functionality. Currently the USGS has one established detector dog team and in February began training a second team which we expect will be proficient at detecting BTS on Guam within the next few months.

Saipan Snake Search Activities.
Nate Hawley and James Stanford.
US Fish and Wildlife Service / CNMI DFW, and USGS Brown Treesnake Rapid Response Team, Guam.

From February 20 to March 12, 2007, a major multi-agency search effort took place on Saipan, as part of an attempt to determine if a Brown Treesnake population is already established on the island. Members of several agencies funded by the Office of Insular Affairs were involved in this initiative with the Commonwealth of the Northern Mariana Islands Department of Lands and Natural Resources, Division of Fish and Wildlife heading up the search efforts. The primary area searched was in and around the Saipan International Airport. This location was selected due to the multiple BTS sightings and specimens recorded in the area within the past 25 years. Several other high-risk areas were also targeted where past snake sightings had been reported. Visual searchers, detector dog teams, and trapping were all used during this search effort. Results are pending.

Spatial Economic Analysis of Early Detection and Rapid Response Strategies for the Brown Treesnake.

Brooks Kaiser and Kimberly Burnett
Gettysburg College (BK) and University of Hawaii at Manoa (BK and KB)

Economic impacts from invasive species, including damages to assets from invasion and the ensuing management costs, may vary significantly across spatially differentiated landscapes. For example, losses due to BTS may be higher in more densely populated native bird communities and closer to major power lines. Additionally, the probabilities of arrival to a new area and subsequent growth should be higher with increasing proximity to the ports of entry. Consequently, returns to management are expected to be greater around these areas.

We consider the effect of these spatial differences on early detection and rapid response activities (EDRR) for BTS on the island of Oahu, Hawaii. EDRR consists of search beyond the ports of entry, where search and potential removal efforts are targeted toward areas where credible evidence suggests the presence of an invader. EDRR costs are a spatially dependent variable related to the ease or difficulty of searching an area, while damages are a population dependent variable. Using Geographical Information Systems (GIS) software, we generate a spatially-explicit optimal EDRR policy given the eventuality that prevention of the snake's entry has already failed or will eventually fail at either the airport or the shipping harbor, regardless of budget. We find that optimally applied EDRR that integrates the costs, damages, and biological parameters of the snakes' potential presence can save the island of Oahu approximately $270 million in present value losses to social welfare over 30 years.

Spotting cryptic animals in the dark: What light properties should a good headlamp have?

Björn Lardner, Julie A. Savidge, and Gordon H. Rodda
Colorado State University, Fort Collins (BL and JS)
USGS Fort Collins Science Center (GR)

Relying on visual detection of cryptic nocturnal animals may present a challenge. This is the case for the invasive brown treesnake (*Boiga irregularis*) that has had profound ecological effects on the native vertebrate fauna of Guam since its establishment in the mid-20th century. Interestingly, there seems to be no published tests of how search light properties affect animal detection rate. We therefore assigned eight biologists to search for dead snakes placed in roadside vegetation. Each person conducted searches on four occasions using lamps with varying properties: weak versus strong light, crossed by narrow versus wide beam. On each occasion, 100 snakes were randomly placed ≤ 5 meters from the transect line and ≤ 4 m above ground. Of these 100 snakes, the mean number spotted on a transect walk was 13.5. Using an information theoretic approach to analyze data, and accounting for confounding variables, model-averaged partial regression coefficients showed that using a spotlight rendered almost six fewer snakes per search than a floodlight (95% CI = -2.6 to -9.1). A weak lamp rendered 3.5 fewer snakes

than a strong lamp (95% CI = -0.3 to -6.7). There was a tendency for an interaction effect in that weak spotlights had an average of two snakes fewer than expected by the main effects alone (95% CI = +2.5 to -6.6). The observer effect was relatively small: seven of eight biologists spotted an average of 12.0 to 14.2 snakes during each search. For some searchers, beam width seemed to be most important; others benefited more from strong lights. We suspect that the benefit of using a lamp with a floodlight beam is particularly pronounced when a complex, 3-dimensional forested habitat is surveyed and when the traveling speed is relatively high (which would preclude scanning all vegetation with a spotlight beam).

A CWCS resource protection partnership: watershed protection, habitat restoration and endangered species recovery

David T. Limtiaco,
Guam Department of Agriculture's Division of Forest and Soil Resources

The mission of the Guam Department of Agriculture's Division of Forest and Soil Resources is to sustain and enhance Guam's natural environment and its resources. The mission of the Guam Division of Aquatic and Wildlife Resources (DAWR) is to manage Guam's wildlife resources for cultural, recreational, and economic benefit of present and future generations. Until recently the two divisions worked fairly independently despite having fairly similar mandates. In 2003, as a condition of receiving State Wildlife Grants, DAWR initiated the Comprehensive Wildlife Conservation Strategy (CWCS). The CWCS is a document that provides guidance for the recovery of native species and their habitat on Guam. It was through the development of the document that the relationship between DAWR and Forestry was enhanced. Since 2002 DAWR and Forestry have partnered to restore native flora and fauna. Protecting and restoring Guam's native forest is the first step to the reestablishment of Guam's endangered species. This presentation will review the Forestry Division's current reforestation programs that benefit urban and wildland watersheds, forest health, and wildlife recovery on Guam.

Cocos Island Rodent Eradication.
Dana. T. Lujan.
USDA – APHIS – Wildlife Services, Guam.

Wildlife Services has entered into agreement with Guam Division of Aquatic and Wildlife Resources to plan and implement a rodent eradication plan and subsequent rodent incursion prevention, monitoring and response plan for Cocos Island. Successful island rodent eradications worldwide have overcome different challenges specific to each island. Cocos Island presents its own unique challenges: the presence of two target species (*Mus musculus* and *Rattus exulans*), bait competition with several crab species, the presence of a locally listed threatened bird subject to non-target loss and some human use of the area in association with a privately owned resort. These challenges have stimulated creative ideas to overcome these issues, such as: strategic timing of the baiting event, exclusionary bait stations, telemetric monitoring of bird populations pre and post baiting, and bait station deployment/retraction strategies. However, the additional challenge is to ensure that these mitigating actions do not compromise the overall success of the eradication.

From television and newspapers to viral videos and toe-tapping jingles
Christy Martin.
Coordinating Group on Alien Pest Species, Honolulu, Hawaii.

The Coordinating Group on Alien Pest Species (CGAPS), a voluntary government/non-government partnership formed in 1995 to promote inter-and intra-agency communication, coordination and public awareness on invasive species. Focusing on public awareness, CGAPS launched a media campaign in 1997 titled “Silent Invasion” which used television news stories, commercials and accompanying newspaper stories featuring “poster species” like Brown Treesnakes. Prior to the campaign, a baseline public awareness study found that 66% of respondents “had heard of Brown Treesnakes”. Subsequent television news and newspaper stories continued to keep people aware of Brown Treesnakes, and in a 2004 survey, 83% of people “had heard of Brown Treesnakes.” The same survey found that 91% of people were “very likely” to report a snake if they saw one, but less than 5% knew that there was a pest hotline, and nobody could recite it. In spring 2006 CGAPS again ran television commercials and stories on snakes and the new pest hotline. A follow up survey showed that 88% of people had heard of Brown Treesnakes, but still don’t know the number. Survey trends also show that while 44% of respondents over 34 years of age believed that invasive species are a “very serious problem”, the 18-34 year old demographic was less inclined to believe that invasive species are a “very serious problem” (32%). Ninety percent of respondents over the age of 34 were “very likely” to report if they saw a snake, while 81% of 18-34 year olds were “very likely to report a snake”. Other trends have lead CGAPS to experiment with new ways to reach the younger, local audiences in the 18-34 year demographic while continuing to use the television and print news media that seems to suit other demographics.

Male behavioral responses to female Brown Treesnake skin secretions

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Responses of "free-ranging" adult males to substrate-born skin secretions of adult females were investigated in an outdoor semi-natural enclosure at the U.S. Fish and Wildlife Service's Ritidian Unit of the Guam National Wildlife Refuge, Guam. Males were given a simultaneous choice of investigating poles to which the scent of either a vitellogenic female or non-vitellogenic female had been applied just prior to onset of male nocturnal activity, or a no-scent control pole (3 replicates per treatment, per night, per female). Males spent more time, and exhibited a greater frequency of investigative "nose-backups", on poles contacted by vitellogenic females than nonvitellogenic females or no-scent controls. In a very limited test of whether the pheromone might also be airborne (1 night, using all females: vitellogenic and non-vitellogenic), no males visited caged females placed within the enclosure (no substrate scent trails leading to cages).

Forecasting the risk of Brown Treesnake dispersal from Guam: a mixed transport-establishment model

Gad Perry and Dan Vice
Texas Tech University (GP) and USDA/APHIS/Wildlife Services, Guam (DV)

The Brown Treesnake is a devastating invader poised to further disperse from Guam to additional locations. At least some potential receiving sites, such as Hawaii, may then experience similar impacts to those already documented on Guam. Interdiction activities and research are ongoing to forestall this, but no tools currently exist for evaluating the potential for snake incursion to various sites, and therefore the amount of effort which should be invested at protecting that particular site. It is also unclear what impact on further spread might occur as the result of successful establishment of the snake at another location, such as Hawaii. We use this example to develop a model which predicts the relative risk of establishment of an invasive species at a given site. To calculate overall risk, the model uses information on the magnitude of the opportunity provided by the transportation network; the likelihood of an organism entering the transportation system, avoiding detection, and surviving to arrive at another location; and the probability that an arriving propagule will be able to establish at the receiving end. To test the model, we used quantitative information (e.g., on the transportation network) and qualitative estimates (e.g., likelihood of detection once within the network) related to the Brown Treesnake and Guam. Information of rates of arrival at receiving sites demonstrate that, despite the imprecise nature of some of the inputs, the model provides a realistic output that can be used by decision-makers. Further, the model can be used to evaluate the impacts of proposed changes in transportation parameters or interdiction effort, as well as the impacts establishment at an additional site, such as Hawaii, would have for locations currently at low risk of snake incursion.

Evaluation of a long-term landscape-level control program to reduce BTS populations.

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USDA – APHIS – WS - National Wildlife Research Center, Hilo, HI (RS), and
USDA – APHIS – Wildlife Services Operations, Guam (DV).

A landscape level control program was established in 2000 in the Munitions Storage Area (MSA) at Anderson Air Force Base. The program consisted of daily trapping of Brown Treesnakes using 957 live traps spaced 25 m apart covering a 400 acre area within the MSA. The goal of the program was to reduce the Brown Treesnake population which would enhance native wildlife populations. In addition, if this program was successful, the area trapped could be enlarged or the technique could be transferred to another area. To this end, we evaluated the initial 250 weeks of trapping while the trapping techniques remained consistent. We evaluated changes in trap capture success, change in snake size, spatial differences in trap success, and the effects of reducing trapping effort on capture success.

Mariana crow recovery on Guam

Jeff Quitigua.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

Mariana crows (*Corvus kubaryi*) historically existed throughout native forest on Rota and Guam. However, the spread of the Brown Treesnake (*Boiga irregularis*) throughout Guam restricted the distribution of Mariana crows to the island's northern forests. Efforts to reverse the decline of the crows began in 1986 with the testing of techniques to protect crow nests from snakes. In the early 1990s, crow nests were protected through the application of electric barriers on nest trees and the use of snake traps. In 1996 the National Research Council completed a review of the Mariana crow recovery program and recommended area snake control and the application of electric barriers to protect active crow nests, as well as the release of captive birds from mainland zoos. Initial efforts to protect crow nests found the aging Guam crow population was no longer producing viable eggs. Starting in 1999, crows translocated from Rota augmented the Guam population; however, the uncertain status of the Rota crow population has led to the suspension of translocation efforts. Currently, nine Marianas crows exist in the wild on Guam through avicultural intervention and translocation efforts by Guam Division of Aquatic and Wildlife Resources. This presentation will review the efforts to protect Mariana crows on Guam and report the first Mariana crow to fledge from a pair of translocated Rota birds.

Climate matching as a tool for predicting potential spread of Brown Treesnakes

Gordon H. Rodda and Robert N. Reed
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Climate matching is often used to predict which destinations could be colonized by a potential invasive species such as the Brown Treesnake, *Boiga irregularis*. Climate is a proxy, and possibly a poor one, for the myriad factors that determine whether a population will reproduce enough to offset mortality. Furthermore, model selection for the appropriate characterization of climate is non-intuitive. Classical climate matching models for Brown Treesnakes incorporated additive effects of univariate climate measures (such as total annual precipitation) from occupied native range sites, but the results were not very satisfying, perhaps because different combinations of climate attributes influence a species' range limits in different parts of the range. We explored the distribution of bivariate clouds of monthly climate variables as a possible tool for predicting high risk destinations. Recognizing that ectothermic vertebrates may aestivate or hibernate to escape seasonally-inclement weather, we developed algorithms that permit up to 2 months of aestivation in the warmer (>20 C) portions of the range, or 4 months of hibernation in temperate climes. Although Brown Treesnakes appear to be limited by dry weather in the interior of Australia, the aridity in central Australia is so extreme that monthly precipitation is of no practical value in delimiting potential range in North America or much of the world. Monthly precipitation in the Brown Treesnake's occupied native range covers at least five orders of magnitude, representing the full range of values present on Earth. Potential colonization area is more sensitive to the model's assumptions regarding the acceptable duration of cold periods, however. Hard data on cold tolerance at an ecological scale are few, especially at the upper altitudinal limit of the Brown Treesnake's range in New Guinea. We explore and critique various algorithms for predicting potential unnatural distribution of the Brown Treesnake, including models contingent on the edge of range under consideration.

Vital rates of Brown Treesnakes (*Boiga irregularis*) from a geographically closed population on Guam.

Gordon H. Rodda, Robert N. Reed, Julie A. Savidge, Michelle T. Christy, Amy Yackel Adams, and Claudine L. Tyrrell.
USGS Fort Collins Science Center, Fort Collins, CO / Guam.

Because the secretive nature of snakes results and relatively low recapture rates in field studies, rigorous demographic analyses of snake populations are rare. This has been the case for the nocturnal Brown Treesnake (*Boiga irregularis*; BTS) on Guam, where it is an infamous invasive species responsible for the elimination of many native vertebrates. It is especially difficult to discriminate population-level trends due to recruitment and mortality from those due to emigration and immigration. The latter can, however, be excluded from consideration by studying a population that is geographically closed. In June 2004, we initiated sampling of BTS in a 5-ha plot on Guam, which is bounded by fences impervious to BTS scaling efforts. The initial population size was 122 snakes, and

sampling has been conducted via visual searching and snake trapping. Since that time, we have recorded >5,000 captures of >170 individuals in the closed population, including numerous hatchlings and either observed or inferred mortality of individuals. The historical elimination by BTS of many large-bodied prey species on Guam has reduced food availability for large snakes, while high-density populations of native and introduced skinks and geckos result in abundant food for small snakes. Demographic results of these altered prey size distributions include extraordinarily high hatchling survival, countered by high mortality of adults, especially adult females. Although hatchling recruitment is relatively low (~0.5 female offspring per adult female per year), population density in the closed population is high and increasing (~25 snakes/ha). These invasive predators exhibit a mortality schedule that appears to be remarkable among terrestrial vertebrates.

The Closed Population project: precise monitoring of a Brown Treesnake population without emigration or immigration allows precise inference about the effectiveness of control tools.

Gordon H. Rodda, Julie Savidge, Michelle T. Christy, and Claudine L. Tyrrell.
USGS (GR) / Colorado State University Brown Treesnake Project, Fort Collins, CO / Guam (JS, MC, CT).

When attempting to completely eliminate a Brown Treesnake (BTS) population (such as on Saipan or in nature reserves on Guam), it is essential to kill every individual. Yet when we carefully test various control tools (e.g., traps, poison bait) in normal field situations on Guam, there are always a few individuals remaining at the end of any control effort. Were those individuals present but unharmed by the control tool, or did they enter the control area just as the study was ending? One solution to this weakness of experimental design is to test the control tools in a fenced plot, where snakes cannot enter or leave. In 2004 we surrounded five hectares (12.5 acres) of Northwest Field, Guam, with a snake-proof fence, and commenced a series of tests of BTS control tools. Before considering the results of those tests (to be presented during other talks at this conference), we evaluated whether the fence was as snake-proof as anticipated, how many snakes (of what sizes) were present in the enclosed forest, and whether the enclosed snakes fared as well as snakes not confined by a fence. None of the 400+ snakes marked outside of the fence have appeared inside, and none of the 200+ snakes marked inside have appeared outside. At the time of closure there were 121 snakes inside, but that number has grown steadily over time: there are now about 175 snakes present. Not only has the number of snakes increased, but their body condition has steadily improved (and improved more so than the unconfined snakes outside the fence). About 1/3 of the resident snakes are small juveniles (< 700 mm SVL), though the proportion changes with fluctuations in mortality and hatching. Tree size and density has increased steadily since closure, presumably a reflection of coincidental ungulate exclusion.

Field evaluations of unadulterated, freeze-dried, and dehydrated dead neonatal mice as baits and live trap lures for Brown Treesnakes.

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USDA-APHIS-Wildlife Services, Guam (MH)

Baits and live trap lures were evaluated on Tarague Beach, Andersen Air Force Base, Guam. Daily bait evaluations with unadulterated dead neonatal mice (uDNM), freeze-dried DNM (fdDNM), and dehydrated DNM (dDNM) were conducted January-February 2006 with open ended 2" x 12" PVC tubes hung horizontally, and July-August 2006 with 3" x 12" PVC tubes hung at 45º. The top end of each 3" x 12" tube had a plastic cap perforated with ¼" holes to exclude entry by snakes and non-target animals. Baits destroyed (e.g., as evidenced by skeletons or skulls) by ants and maggots were not used in calculating consumption of baits (bait-take). Four-day cumulative bait-take from 2" x 12" bait tubes was: uDNM, 86% (n= 44); fdDNM, 84% (n= 49); and dDNM, 73% (n= 48). Six-day cumulative bait-take from 3" x 12" bait tubes was: uDNM, 96% (n= 15); fdDNM, 55% (n= 18); and dDNM, 48% (n= 12). Bait-take did not differ significantly among treatments ($p > .05$) in either the four- or six-day cumulative test periods. Randomly selected 3" x 12" bait tubes were monitored by infra-red video camera for 1,264 h and tapes scored for animal activity. Except for ants, flies, and Brown Treesnakes, no other animals visited the bait tubes.

Five live trap lure treatments (empty trap, live mouse, uDNM, fdDNM, dDNM), totaling 180 trap-nights for each treatment, were evaluated for capturing snakes. Traps were checked daily for 6 days and captured snakes removed daily from the site. Total snakes captured for each treatment was: empty trap, 0; fdDNM, 1; dDNM, 2; uDNM, 10; and live mouse, 95. The only non-target animals captured were 2 land hermit crabs *(Coenobita* sp.*)* in a uDNM lure treatment trap. Except the empty trap, randomly selected trap lure treatments were monitored by video camera for 1,814 h. The only animals that visited the live traps were ants, flies, and Brown Treesnakes.

Field evaluations: Paper products for aerial delivery of baits and mechanical mice as live trap lures for Brown Treesnakes.

Peter J. Savarie, Tom C. Mathies, Kenneth L. Tope, and Kathleen A. Fagerstone.
USDA-National Wildlife Research Center, Fort Collins, CO

Four commercial white paper products (single- and double-ender marking flags, cups, and plates) were evaluated as aerial flotation devices for delivery of baits to Brown Treesnakes in the forest canopy. The products were hand-deployed from a helicopter on the U.S. Naval Computer and Telecommunications Station (NCTS), Haputo Beach Road, Guam. A dead neonatal mouse (DNM) with a glued-on radio transmitter was attached to each of the flotation devices. Ground or canopy location of the DNM was determined by radiotelemetry. DNM entanglement in the canopy for the single-ender flags, double-ender flags, cups, and plates was 85% (17/20), 95% (19/20), 67% (10/15), and 80%

(12/15), respectively. Single-ender flags are preferred because they are less expensive than double-ender flags and baits can be more conveniently attached to them with glue as compared to cups and plates that use thread for attaching baits.

Two types of mechanical mouse (MM) lures were evaluated for capturing snakes in live traps on NCTS and Tarague Beach. MM were activated by either an electronic (MM 1) or a quartz clock movement (MM 2). Snake capture in seven live trap treatments: (1) no lure, (2) live mouse, (3) dead neonatal mouse [DNM, source of dead mouse odor], (4) MM 1, (5) MM 1 and DNM, (6) MM 2, and (7) MM 2 and DNM. Each trap treatment was evaluated for 80 trap nights. Thirty-two (32) snakes were captured with the live mouse lure, 9 with MM 2 and DNM, 4 with DNM, 2 with MM 1 and DNM, and 1 with no lure. No snakes were captured with either the MM 1 or MM 2.

The Rapid Response Team: Past, present, future.

James Stanford and Rebecca Stafford.
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The Rapid Response Team (RRT), funded by the Office of Insular Affairs, was established in 2001 to provide a multi-agency network of trained personnel across the Pacific to respond to Brown Treesnake (BTS) sightings. The response mechanism is twofold, responding to both newly transported snakes and to potential incipient BTS populations. The RRT office is located on Guam to facilitate BTS search training. The RRT is coordinated by the USGS and is supported by a staff of research biologists. Team members attend 3 weeks of training on Guam. A wide array of BTS skills are covered during the 3 weeks, including visual searching, trapping, working with detector dog teams, handling venomous and non-venomous snakes, and many other topics. RRT has continued to grow since its inception and now has roughly 50 trained searchers spread across 13 Pacific Islands and the US mainland. In 2007, we anticipate increasing the number of trained team members, furthering our outreach efforts to the freely associated states of Micronesia, and fine-tuning our detector dog efforts.

Cocos Island Guam rail project: ko'ko for Cocos

Diane Vice.
Guam Department of Agriculture's Division of Aquatic & Wildlife Resources.

The Guam rail *(Gallirallus owstonii*), known as ko'ko in Chamorro, is a flightless bird endemic to Guam. By the mid 1980s the ko'ko' and other forest bird populations on Guam were devastated by the introduced Brown Treesnake (*Boiga irregularis*). Attempts to establish ko'ko' in snake-reduced areas on Guam have had limited success. Although the ko'ko' were able to reproduce in the presence of snakes, establishment was limited due to the presence of feral cats in a heavily browsed habitat. Cocos Island provides a unique opportunity for Guam – the island is free of cats, deer, pigs, and possibly snakes.

A few individual snakes reported on Cocos Island may indicate an incipient snake population, however efforts to detect snakes have been unsuccessful. The island provides a safe haven for nesting seabirds, the locally endangered Micronesian starling (*Aplonis opaca*), and native lizards no longer found on Guam. The few reports of snakes found on Cocos indicate the vulnerability of the island to snakes and other invasive species. This presentation will provide an overview and status report of management activities planned to protect Cocos Island from invasives and to establish free-ranging ko'ko' on Cocos Island.

Introduced rodent and shrew densities and distributions in the Mariana Islands: Implications for Brown Treesnake control and management.

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Introduced rodent and shrew populations play an important role in Brown Treesnake (*Boiga irregularis*) control and management. Current Brown Treesnake control efforts are highly dependent on traps using live domestic mice (*Mus musculus*) as attractants. Research conducted on Guam suggests that the effectiveness of these traps is inversely related to introduced rodent (*M. musculus, Rattus exulans, R. norvegicus,* and *R. rattus*) and shrew (*Suncus murinus*) densities. Unfortunately, information about introduced rodent and shrew densities on Guam, Rota, Saipan, and Tinian is limited. Thus, our objective was to develop a robust and repeatable mark-recapture sampling methodology to determine introduced rodent and shrew densities in the major habitat types of Guam, Rota, Saipan, and Tinian. During 2005 and 2006 we sampled 9 sites on Guam, 4 sites on Rota, 5 sites on Saipan, and 3 sites on Tinian. These sites were located in grassland, introduced forest dominated by *Leucaena leucocephala*, and native forest habitats, or near airports and seaports. In general, introduced rodent and shrew densities were higher on Rota, Saipan, and Tinian than on Guam. *R. rattus* densities were high in all habitats on Rota, Saipan, and Tinian. *S. murinus* densities were moderate to high in all habitats on Saipan and Tinian; this species was not observed on Rota. *M. musculus, R. exulans*, and *R. norvegicus* exhibited patchy distributions and variable densities on all islands. These data suggest that Brown Treesnake control and management tools that rely on mouse attractants will be less effective on Rota, Saipan, and Tinian than on Guam. Further, if the Brown Treesnake becomes established on these islands, high-density introduced rodent and shrew populations may facilitate and support a high-density Brown Treesnake population, even as native avian and reptilian species are reduced or extirpated.

Poster Paper

Disruption of hemoglobin species balance in Brown Treesnake blood by lethal oral dose of acetaminophen.

Tom Mathies and Lowell A. Miller.
USDA – APHIS – WS - National Wildlife Research Center.

Acetaminophen is registered with U.S. EPA (EPA Reg. No. 56228-34) as an oral toxicant for Brown Treesnake control. In most vertebrates, acetaminophen toxicity is through symptomatic hepatotoxicity, and to a far lesser extent, methemoglobinemia. Methemoglobin cannot bind O^2 and is only slowly converted back to normal hemoglobin, thus mortality is by anemic hypoxia. Hepatotoxicity, however, is apparently not the proximate cause of mortality in Brown Treesnakes: Brown Treesnakes that have ingested the standard 80 mg dose typically die prior to the time generally needed to incur hepatotoxicity. Further, histological examination of livers of Brown Treesnakes that died from a lethal dose showed no liver damage. This study was therefore undertaken to examine the effects of acetaminophen on methemoglobin formation. Snakes were assigned to two groups; gavaged with either one 80 mg tablet of acetaminophen, or a vehicle control. Individuals of both groups were sampled every 2.4 h up until the median time to death (14.4 h; 6 sample groups). Percent methemoglobin (MetHb), deoxyhemoglobin (RHb), oxyhemoglobin (0_2Hb), carboxyhemoglobin (COHb), and total hemoglobin (tHb) were measured using an IL 682 Co-oximeter. Mean %MetHb increased to a maximum of 49.6% (baseline = 1.3%) 12 h post-dosing. Mean %0_2Hb (oxygenated blood leaving heart for brain) decreased a minimum of 44.2% (baseline = 80.0%) 12 h post-dosing. Acetaminophen severely disrupted the normal 1:1 relationship between species blood levels of 0_2Hb and RHb. %0_2Hb, which is normally unrelated to %MetHb, was linearly related to %MetHb ($R^2 = 0.88$).