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Non-Indigenous Species: Government Response to the Brown Tree Snake and Issues for Congress

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Non-Indigenous Species: Government Response to the Brown Tree Snake

SUMMARY

Species found abundantly outside of their normal range can represent an ecological and economic hazard as great or greater than the most far-reaching efforts to protect an endangered species. One current example is the brown tree snake (*Boiga irregularis*). This species invaded Guam from its native habitat in New Guinea and Australia in the 1950s. Its effects include not only major disruptions of electric power transmission, telephone service, military operations, computers, and tourism, but also devastation of the island's bird life. While only mildly poisonous, the snakes have bitten over 200 sleeping humans, including infants. Their secretive behavior predisposes these aggressive nocturnal snakes, which may reach 10 feet long, to stow away in ships and airplanes. Hawaii and the Commonwealth of the Northern Mariana Islands are at particular risk of invasion by this species, but Gulf Coast states, southern California, and Puerto Rico also face some risk. The issue for Congress is oversight of coordination among federal agencies and other institutions, and funding levels for research, control, and prevention of the spread of this species.

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Non-Indigenous Species: Government Response to the Brown Tree Snake

Economic Damage of Introduced Species

Concerns over biodiversity have focused on the loss of species, but an abundant species where it does not belong can be an even more severe problem, not only biologically but also economically. Some plants, for example, have been notorious for years for causing both economic and ecological damage; kudzu, melaleuca, tamarisk, purple loosestrife, spotted knapweed, and Russian thistle are just a few examples of unwanted plants now creating ecological and economic havoc in large areas of the United States. Their damage includes lowering water tables, competing with other plant species, poisoning livestock, and increasing pest control costs. Introduced invertebrate pests are even more obvious: gypsy moths, Japanese potato beetles, fire ants, Africanized honeybees, and zebra mussels are among the most well-known. Introductions of vertebrate pests (e.g., walking catfish, cane toad, monk parakeet, starlings, and feral goats) are comparatively rare, aside from fishes.

In some of these cases (e.g., kudzu, melaleuca, gypsy moths, Africanized bees, zebra mussels, and starlings), the source of the introduction is either known or strongly suspected. Governments at all levels might have worked to prevent these introductions at the time, had they foreseen the damage these species would later cause.

For any introduced species, the range of control actions falls into six basic categories: (1) baits and attractants; (2) fumigants, repellents, and barriers; (3) traps; (4) poisons; (5) biological controls; and (6) bounties and commercial exploitation. The entire arsenal is unlikely to be used on any given species for a variety of reasons: lack of information needed to implement the approach; probable effects on non-target species; expense; and risk of providing economic incentives to spread the pest species to other locations, to name a few.

Federal Framework for Non-Indigenous Species

According to a study on control of non-native species by the Office of Technology Assessment (OTA), "(t)he current Federal framework is a largely uncoordinated patchwork of laws, regulations, policies, and programs. Some focus on narrowly drawn problems.... In general, present Federal efforts only

partially match the problems at hand."[1] One impediment, according to the study, is the federal focus on preventing the entry of specific agricultural pests rather than on species harmful to other sectors of the economy. (The brown tree snake (BTS-*Boiga irregularis*) does represent a threat to agriculture, but only indirectly: it feeds on birds, many of which may feed on insect pests.)

A second legal impediment to federal control of non-indigenous species, according to the OTA study, is that entry of harmful species may be prohibited under such laws as the Lacey Act and the Federal Noxious Weed Act only after the species has become established or caused damage within the United States. Paradoxically, the species covered by these laws can be legally imported until it is established, or at least classified as injurious, and added to a list, *after* which it may not be imported. Additions to the controlled list can be costly and time-consuming. Agencies fear lawsuits from interested groups such as agriculture and the pet, aquarium, and horticulture trades if they add a species to a controlled list without proof that it is harmful.[2]

The OTA study reviewed the responses of numerous federal agencies to the problem of unwanted introductions. These agencies included the Animal and Plant Health Inspection Service (and specifically its Animal Damage Control program) in the Department of Agriculture, the Defense Department, and the Fish and Wildlife Service (FWS) in the Department of the Interior. The study noted that "current shortcomings of the FWS law enforcement division might compromise expanded efforts" to play a greater role in regulating import of species. (The Biological Resources Division of the U.S. Geological Survey did not exist at the time of the OTA study, but its research efforts on the biology of some non-indigenous species are significant, and could lead to control techniques that might be implemented by other agencies.) Interestingly, the brief OTA discussion of the Department of Transportation did not mention the Federal Aviation Administration, whose role in regulating and managing commercial air traffic and airports might be critical for some pests.

Partly as a result of gaps in current law, but particularly because of the introduction of the zebra mussel into the Great Lakes and Mississippi River Basins, Congress passed the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA; P.L. 101-646). The stimulus was the huge economic impact on utilities from the prolific zebra mussel due to the clogging of pipes, drains, etc. The impact of the zebra mussel on imperiled native clams and mussels was a relatively minor consideration.

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[1]U.S. Congress, Office of Technology Assessment. *Harmful Non-Indigenous Species in the United States*. OTA-F-565. Washington, DC: U.S. Government Printing Office, September 1993. p. 163. (Hereafter referred to as the "OTA study.")

[2]Examples of laws which rely on listing noxious species as a prelude to exclusion or regulation are the Federal Noxious Weed Act (7 U.S.C. 2809, administered by APHIS), and the Lacey Act (16 U.S.C. 3371, administered by FWS).

The Brown Tree Snake Example

The brown tree snake (BTS) is native to New Guinea, various nearby Pacific Islands, and northeastern Australia. It lives in trees, where its agility helps it to find its chief prey of birds and small mammals.[3] Its mild venom is used to immobilize its prey. The propensity of this nocturnal snake to seek daytime shelter from heat and sun in confined and hidden spaces, as well as its very high population densities on some islands, make it a pre-adapted stowaway. The species was introduced to Guam, an important Navy and Air Force base, in the 1950s. Most likely, it arrived as a passive stowaway in one of many military cargo ships moving material in the aftermath of World War II.[4] By the late 1960s it had spread throughout the island. The BTS has wandered into, among other places, the wheel wells and cargo holds of large aircraft. And a cargo ship moving from Guam to Diego Garcia in the Indian Ocean was the most likely source for a brown tree snake seen at the military base there.

With an abundant prey base and lack of natural predators in Guam, the species has built populations as high as 12,000 per square mile. More than 200 people have been treated for bites, with attacks occurring primarily on people asleep in their beds. Occasionally, babies have been attacked, and numerous small household pets have been eaten. By crawling on electrical lines, the snakes cause frequent power outages, sometimes affecting the entire island, both military and civilian facilities.

Why Islands are Vulnerable to Biological Invasions

In general, island species are more vulnerable than mainland species when non-native species are introduced, due to the island species' evolution in relative isolation from mainland predators, diseases, and/or competitors. The more remote the islands, the more isolated and therefore vulnerable they are. Birds, for example, that have lived for millennia on a snakeless island, usually lose their mainland relatives' defenses, such as hidden or inaccessible nests, fear of snakes, attacking snakes near their nests, etc. Perhaps no islands are more vulnerable to introduced species than Hawaii, the planet's most isolated archipelago. Hawaiian fauna is under siege from introduced species of birds, mosquitoes transmitting avian malaria (formerly absent from the islands), rats, and other non-natives.

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[3]For a discussion on BTS biology and effects, see report of *The Brown Tree Snake Control Plan*, report of the Brown Tree Snake Control Committee, Aquatic Nuisance Species Task Force. June 1996. 55 p. For photographs and maps, see *http://www.discovery.com:80/DCO/doc/1012/world/nature/snakes/snakes1.html* (noperiod at end of web address).

[4] U.S. Dept. of the Interior, Fish and Wildlife Service. *The Brown Tree Snake,* Boiga irregularis, *A Threat to Pacific Islands.* Biological Report 88(31). Washington, DC: September 1988. p. 5. (Hereafter referred to as *BTS Threat.*)

On average, these outages occur once every four days; in 1996, the snakes caused over 170 outages on the island. Results include spoiled food, computer failures, increased business losses, etc. The decline of the island's bird fauna seems likely to increase crop loss to insects and reliance on more costly chemical controls. Once established, the BTS has proven impossible to eradicate and extremely difficult to control.

The snakes first came to the attention of mainland biologists after puzzling reports of the crash of the island's bird populations. Eventually tracing these crashes to the BTS, biologists now lay the loss of at least 9 of the island's 11 native land bird species (including some found nowhere else) on the snake.

In a comprehensive 1988 report on the BTS, the FWS considered the six basic methods of pest control for their applicability to this species.[5] (See Appendix, p. 11, for a discussion of these methods as applied to the BTS.) None is considered fully effective at control, much less eradication. The FWS report holds out far more hope of preventing dispersal to other islands of the Pacific than that the snake can be eliminated where it has established a foothold. An appendix in the FWS report outlined a plan for control and eradication of the BTS with detailed research proposals and sketchy plans for actual control of the snake--reflecting the low level of basic knowledge about this pest. To date, all approaches have been deemed to suffer from lack of funding.

NANPCA and the Brown Tree Snake

Though the BTS is not aquatic, one provision (16 U.S.C. 4728) of NANPCA gave authority to a Task Force to "undertake a comprehensive, environmentally sound program in coordination with regional, territorial, State and local entities to control the brown tree snake (Boiga irregularis) in Guam and other areas where the species is established outside of its historic range." It is interesting to note that, taken at face value, this wording conveys no authority to *prevent* the introduction of the BTS, an endeavor which seems far more likely to succeed than efforts to control the species after it is established. More general provisions for the Task Force arguably allow attention to problems of preventing the further dispersal of the snake. Certainly the final report on a BTS control plan emphasizes prevention.

The resulting Task Force, chaired by FWS[6], has federal representatives from the Geological Survey, the Department of Defense (DOD), and APHIS. The Guam Department of Agriculture, the Hawaii Department of Agriculture, the Department of Land and Natural Resources of the Commonwealth of the Northern Mariana Islands, and the University of Guam Marine Laboratory are also members. Initial implementation of a number of BTS provisions of

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[5]*BTS Threat*. 36 p.

[6]Perhaps due to the heritage of authorization in a law intended primarily to prevent aquatic nuisance species, the BTS program in FWS is under the Assistant Director for Fisheries.

NANPCA by the Task Force was sketchy or delayed due to inadequate funding, failure to allocate sufficient staff, and legal conflicts in chartering the Task Force (e.g., compliance with the Federal Advisory Committee Act). But the *Control Plan* (cited above) has been completed, and agencies are generally following its outline.

Arrival in Hawaii and Other Destinations?

Hawaii, especially Oahu, is very much at risk for the next invasion of the BTS, as is the Commonwealth of the Northern Mariana Islands (CNMI--a U.S. territory), according to the *Control Plan*, as well as most experts. If the snake were to become established on Oahu, its spread to the other islands of the state would seem inevitable, given the snake's behavior and the heavy traffic among the islands. If successful in its invasion, the snake's effects on the islands' power grids, computer systems, tourism, etc., while difficult to estimate, would certainly be substantial, based on the Guam experience.

Both military and civilian flights between Hawaii and Guam occur daily, providing potential for snake stowaways. Despite a prevention program, BTSs have been found on at least seven occasions in Hawaii (at Honolulu International Airport, Barbers Point Naval Air Station, and Hickham Air Force Base), on or near aircraft arriving from Guam. To date, their dispersal has been prevented.

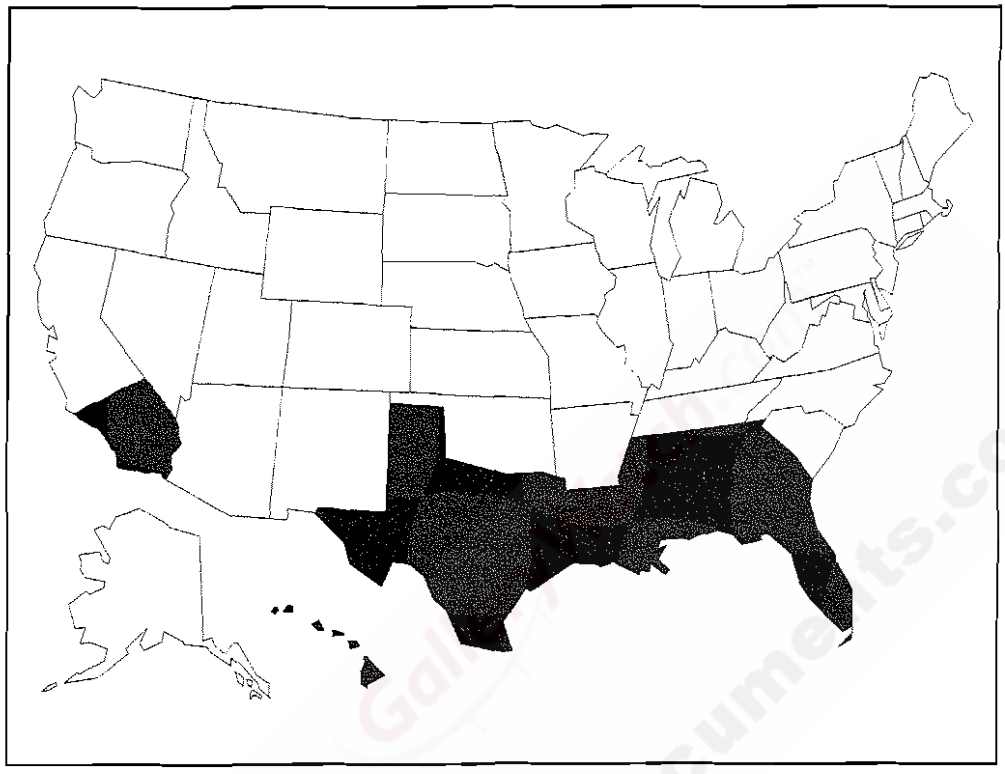
Military and civilian cargo ships are also potential sources of transport of the BTS, not only to Hawaii and the CNMI, but also to the mainland. One snake was found in a cargo of military household effects arriving in Texas. Potential mainland habitat includes portions of southern California and Gulf Coast states, as well as much of Central and South America. (See figure 1.) Mainland states, with well-established populations of snake predators (e.g., certain bird species, and perhaps some weasels) might be less likely to see the huge snake population densities now seen in Guam, or potentially threatening Hawaii and the CNMI, but this possibility is not proven. Specific areas at risk on the mainland are those warm habitats containing trees and shelter near airports, and dock facilities that receive foreign passengers and cargo from affected areas.

Preventing the Spread of Brown Tree Snakes

The U.S. Customs Office and the Animal and Plant Health Inspection Service (APHIS) together inspect about 15% of international air carrier baggage entering or passing through Honolulu. In contrast, APHIS x-rays 100% of the baggage bound from Honolulu to the mainland. This reflects a greater concern for Hawaii as a source of bio-contamination, than as a recipient of it.[7] (See

[7]OTA study, p. 250.

Figure 1. States with some potential habitat for brown tree snake. (source: The Nature Conservancy. *America's Least Wanted.* 1996. p. 21.) Puerto Rico (not shown) would also be a potential BTS habitat.



box.) This asymmetry of protection efforts is a source of concern to Hawaiian citizens.[8] Military and civilian maritime cargo to Hawaii is irregular, and shipments undergo irregular APHIS examination.

Trained detection dogs are important in screening incoming planes. In June 1996 in Hawaii, there were two such fully-trained dog/handler teams and two other teams in training. The number of teams is not adequate to provide full inspection of all incoming military and commercial aircraft and cargo, nor regular inspection of maritime transport. Five to eight dog/handler teams are working in Guam, but are not sufficient to provide full coverage for all outgoing flights and shipments. The effectiveness of these dogs either on Guam or Hawaii has not been established. According to FWS employees, the dogs sometimes miss snakes later found by humans with flashlights, and sometimes give false alert signals for non-target species, such as rats.

Public Education

Control of the BTS and prevention of its spread are unlikely to show much success without public awareness of the problem. The military in Guam has instituted BTS awareness programs even among personnel without direct

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[8]For example, see remarks of Sen. Daniel Akaka, *Congressional Record*, April 8, 1992, p.S5085-S5092.

responsibility for snake control and eradication. A video showing the general problems of non-native species introduction has been instituted on certain flights to Hawaii from the mainland; these are not shown on flights from Guam. The film is said to be quite friendly, and may play an important role in preventing innocent introductions by the unsuspecting; but some suggest that a film with more emphasis on penalties may be required to stop hobbyists and professionals travelling with illegal seeds, ornamental or edible plants, aquarium fish, exotic pets, etc. These shipments are potentially harmful in themselves, and might inadvertently conceal young BTSs.

Snakes vs. Trade

An import policy specific for Hawaii might be contested under international agreements to reduce trade barriers. For instance, requiring extensive inspections of containers from regions harboring the BTS could be viewed by an importer or exporter as an unfair restraint of trade, though the federal government could argue that the restrictions were permitted under various agreements' provisions to protect health and environment. Consequently, a dispute over restrictions designed to protect the Hawaiian environment might be problematic. On the other hand, a U.S. position giving special protection to Hawaii might appear to contradict stated U.S. policies objecting to European restrictions on certain U.S. products on environmental grounds.

A Tangle of Appropriations

Federal funding for the Brown Tree Snake Control Task Force (CTF) and the control plan it produced is complicated due to transfers of funds among various federal agencies. Some order is given to this confusion by the control and prevention plans in the report. One participant in the CTF said that as long as funds are spent according to the plan, then the goals of the plan should be achieved, regardless of where the appropriations are initially allocated. For example, DOD (with less expertise on pest control) has transferred some of its funding to APHIS to carry out control efforts on military bases. Table 1 shows recent funding levels for various federal agencies involved in control and prevention of BTSs.

Current Controversies

Lack of funding, especially at early phases of a threatened introduction, is a problem in preventing the spread of nonindigenous species.[9] Moreover, the support of some agencies for funding for their control has been lukewarm. For the BTS, the number of dog/handler teams available for inspecting cargo, aircraft, and ships is insufficient to inspect more than about half of the

[9] *America's Least Wanted: Alien Species Invasions of U.S. Ecosystems.* Bruce A. Stein and Stephanie R. Flack, eds. The Nature Conservancy. Arlington, Virginia, p. 9.

shipments at risk, and the effectiveness and training of these teams has not been evaluated thoroughly.

The location of airports receiving shipments from Guam and other places where the BTS is established clearly affects the risk of the spread of this species. An escaped BTS in Anchorage, Alaska, is unlikely to survive, but an escapee at Homestead Air Force Base outside Miami, or at the commercial airport in San Juan, Puerto Rico, well might. Less recognized is that habitat in the area immediately surrounding an airport may encourage or inhibit the spread of the species: surrounding acres of parking lot may aid detection, while nearby tropical or subtropical forest may increase the chance that the escapee may survive. A proposed expansion of a commercial airport on Maui to permit the arrival of long-range flights could be near suitable snake habitat and therefore present a greater risk of introducing this or other non-native species to the state. Ironically, if the expansion airport resulted in establishment of a BTS population on Maui or other islands, the expansion could severely harm the Hawaiian tourism industry it was intended to support. An Environmental Assessment of the expansion is currently underway and is expected to evaluate pest problems. Congress may wish to consider oversight on the location and design of civilian and military airports and docking facilities at risk of receiving brown tree snakes in cargo and baggage.

A larger issue is the *ad hoc* federal management of introduced species. Fragmented authorities and a tendency to respond seriously at a point well after prevention -- when measures are most likely to be biologically and economically efficient -- are quite clear in the various agencies' response to this species over the last 40 years. The fairly strong federal, state, and local response shown for the BTS (with both breadth and significant financial commitment) in the last 5 years or so was preceded by decades of inability of field experts to gain the attention of higher authorities. If the efforts currently shown in preventing BTS introduction in Hawaii had been made 30-40 years ago in Guam, the effects on Guam's economy might have been much reduced, and the snake might have been prevented from becoming established. The BTS's spread to the CNMI could, according to some observers, be at a similar stage. If the lessons of Guam have been learned, then control methods will be brought to bear very quickly on the very small BTS population--literally, an overkill, at least for the time being.

The OTA study cited above suggests that a response after the most economically efficient time is the rule rather than the exception. The general problem (of delayed responses) could appear on the congressional oversight agenda. In the BTS case, problems of federal response remain, since "at current levels [research] will not be sufficient to develop the new techniques that will be required to meet brown tree snake control objectives."[10] Some techniques likely to offer higher chances of eradication (e.g., biological controls) require especially high research commitments.

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[10] *BTS Control Plan*, p. 4.

Table 1. Federal appropriations (actual and proposed) for brown tree snake programs, FY1990-1998. APHIS is not shown since virtually all of its funds are transfers from agencies shown here. (x $1,000.) (Source: Robert Peoples, Nonindigenous Species Coordinator, Fish and Wildlife Service. FY1998 numbers are estimates.)

Agency/Program	1990	1991	1992	1993	1994	1995	1996	1997	1998
Fish and Wildlife									
ESA (Section 6)	226	288	297	250	275	324	449	450	450?
(directly related to BTS control)	(100)	(147)	(147)	(99)	(100)	(100)	(200)	(200)	(200?)
NIS	-	-	-	-	-	86	40	75	192
Research	62	85	59	209	-	-	-	-	-
ESA Recovery	-	-	25	-	-	-	114	-	-
Federal Aid (P-R)	-	3	5	13	12	145	88	9	?
Other Agencies-DOI									
NBS/USGS	-	-	-	-	65	65	165	75	75
Office of Insular Affairs	1,000	148	598	590	650	595	763	795	1,600
Other Agencies-DOD									
AFPMB	-	-	-	1,000	1,000	1,000	1,000	1,000	1,000?
Legacy Program	-	-	320	367	598	536	-	283	300?
Federal Total	1,288	524	1,304	2,429	2,600	2,751	2,619	2,687	3,617?

Abbreviations: ESA = Endangered Species Act; NIS = Nonindigenous Species Task Force, funded through FWS fisheries program; P-R=Pittman-Robertson program, also called Federal Aid in Wildlife Restoration, a grant program to states and territories for wildlife conservation; DOI=Department of the Interior; NBS/USGS=National Biological Service/U.S.Geological Survey, and specifically the BTS program transferred from NBS to USGS after the demise of the NBS; AFPMB=Armed Forces Pest Management Board.

To some extent, the OTA study noted a larger problem: the tension between eliminating the entrance of harmful species, and allowing the entrance of useful or desirable ones. At present, for intentional introductions, species are permitted to enter the country unless they have been shown to be harmful (particularly as agricultural pests), and placed on a list for regulation. The burden of proof is on those who would prevent introduction to show that a species is harmful. One federal regulator claimed that his agency feared being sued unless it could show quite clearly that a species posed a threat. Where harm is less clear, it seems likely that species will be allowed to enter and at least some of these will ultimately cause harm.

For unintentional introductions, certain paths and avenues can be identified, and opposition consists only of those who might be harmed by effects like delay or paperwork (rather than the purposes) of control measures. For one of these avenues, aquatic nuisances arriving via shipping, NANPCA is Congress' response. Other predictable avenues--air cargo, air passenger traffic and baggage, and commercial shipments of legal organisms--are less directly addressed, unless the importation clearly risks fairly direct harm to agriculture or human health. Where the threat is to a region's power grid, communications system, or other industries, preventive measures are minimal for many potential avenues of pest transport.

Appendix: Basic Methods of Pest Control for the Brown Tree Snake

For any introduced species, the range of control actions falls into six basic categories: (1) baits and attractants; (2) fumigants, repellents, and barriers; (3) traps; (4) poisons; (5) biological control; and (6) bounties and commercial exploitation. To apply any of these basic strategies to the control of the BTS, substantial knowledge of the snakes' behavior, biochemistry, prey preferences, diseases, or other aspects of its total biology may be essential. The pros and cons of these six strategies and their information gaps are described below.[11]

Baits and Attractants

Baits and attractants may be used to draw an unsuspecting snake toward a potential food source or mates; once there, they can be counted, killed, or studied. Dead meat items, even dog food and pork spare ribs, have been consumed by free-ranging BTSs. Traps using caged live mice as bait are currently used to protect the perimeters of military bases in Guam. In some snake species, it is known that chemicals given off by snakes allow males and females to find each other; these chemical communication signals are called "pheromones." While no such chemicals are known for BTSs, their discovery could be a powerful species-specific control method. Difficulties with baits and attractants commonly include the need to check the traps and the need to prevent non-target species from being harmed by or interfering with the bait. Baits and attractants seem most promising when the area needing protection has a clear boundary or well-defined area, and a significant density of snakes. Sex pheromones hold the added possibility of functioning even when snake densities are low.

Fumigants, Repellents, and Barriers

Substances might be found which kill BTSs or drive them from an area. Other snake species are known to try to evade certain substances including tear gas and gasoline. Obviously, these substances can be used only to a limited extent, and probably not over large areas. Fumigants seem especially promising in driving snakes from confined areas such as cargo containers and the like, provided that these containers do not require frequent human access. Recently, the Environmental Protection Agency has approved methyl bromide as a fumigant for this species. Light is also known to repel this nocturnal snake. Physical barriers are used to prevent the snakes from climbing onto telephone and electrical wires, among other things.

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[11]The discussion below draws heavily on p. 18-20 *in* U.S. Dept. of the Interior. Fish and Wildlife Service. *The Brown Tree Snake,* Boiga irregularis, *A Threat to Pacific Islands*. Biological Report 88(31). Washington, DC: September 1988. The *BTS Control Plan*, cited above, was also used extensively.

Traps

The use of traps is limited primarily by cost, time to service the traps, and inability of traps to control the snakes over a very large area. Various designs are used, and most are used in combination with some sort of bait. One type of trap consists of two chambers. The inner chamber holds a mouse that cannot be reached by a snake. The outer chamber has a funnel opening through which the hungry snake may enter but not exit. For confined areas such as cargo holds, buildings, etc., these traps have had notable successes. On the other hand, they have obvious drawbacks in an open situation with either abundant alternative prey or very low snake densities. Sticky traps used in rodent control have also been used on BTSs. Trapping methods are comparatively safe for humans, though they require some care when the snake in the trap is killed and removed.

Poisons

There are no poisons registered specifically for snake control. Broadly toxic substances would risk harming other species. A poison would most likely have to be used in conjunction with baits to reduce the risk to pets, children, and other non-target organisms.

Biological Controls

A biological control preys on, parasitizes, or causes disease in a targeted pest species. Ideally, it attacks that species and no others. Considerable knowledge of the BTS's basic ecology would be necessary to select a suitable control. Mongooses are often mentioned as potential snake predators. However, none of the known species of mongoose prey selectively on snakes. Where they have been introduced, they quickly turn to feeding on other species, often leading to further endangerment of native fauna. In the case of the BTS, mongooses are particularly unsuitable, since they are diurnal: nocturnal BTSs are likely to be hidden and inactive when the mongooses are hunting. The introduction of the king cobra, one of the very few truly selective snake predators, seems bound to cause objections.

A disease or a selective parasite seem like a particularly attractive option for the BTS, since in many instances, few or no other snakes live in the areas at risk of invasion[12], thereby decreasing the chance that the disease or parasite will attack a non-target species. Unfortunately, little or nothing is known about any diseases or parasites to which this species may be susceptible. Field work in the species' native habitat would be necessary to find them. Though the requisite research might be expensive, biological control holds out great hope for long term control.

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[12]One native snake, a burrowing blind snake, lives on Guam. One might speculate that its habitat is so different from that of the arboreal BTS that it might still be safe from the disease or parasite, even if it could theoretically be infected. Research would be necessary to determine the risk.

Bounties

Under a bounty system, someone is paid to catch the target species. (Commercial exploitation serves the same purpose.) However, the BTS is an aggressive, nocturnal, secretive, and somewhat venomous species. Hand-trapping would require training in the habits of the species. Capture at night would present serious logistic difficulties, especially if the snakes dropped below abundant levels. According to most sources, people generally find these snakes repellent, and high bounties would probably have to be paid to have a substantial effect. If BTS population levels dropped substantially, bounties sufficient to stimulate some people to continue to search for fewer and fewer snakes might encourage others to raise snakes in captivity to reap the bounty. In a worst case scenario, citizens of other islands with incomes below those on Guam might consider importing BTSs in order to reap the bounty fee.

Summary of Control Methods

Control of the BTS is really two related problems: eradication where that is possible, and reduction to bearable levels where eradication is not possible. No single method of snake control would be a panacea. None so far promises eradication under any conditions in which the snake is well-established, but several in combination *and used indefinitely* might reduce the Guamanian BTS population to tolerable levels. On the other hand, if many are used intensively and in combination they might succeed in eradicating the very small population on Saipan (CNMI) that is threatening to become established--if it is not already.

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