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Boiga irregularis (Brown Tree Snakes) on Guam and Its Effect on Fauna

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Introduction

The island of Guam, a U. S. Territory, is located in the tropical western Pacific, nearly equidistant from Japan to the north, the Philippines to the west, and New Guinea to the South (Enbring & Ftitts 1988). The island is longer than it is wide and is divided into a diverse landscape with forests and cliffs in the north and primarily savannas and river valleys in the south (Savidge 1987). Guam is also a land of great biodiversity including small mammals, reptiles, and numerous bird species; however, snakes are not a natural part of this biodiversity. The burrowing blind snake (*Rhamphotyphlops braminus*), the only native snake to Guam, does not pose a threat to the fauna, yet the introduction of *Boiga irregularis* (brown tree snake) has threatened the island's biodiversity. *Boiga irregularis* a native to Indonesia, New Guinea, Solomon Islands, and Australia, was introduced to Guam by way of navy vessels shortly after World War II where it is an exotic and invasive species (Butler 1997). As a result of its accidental introduction and population explosion, *Boiga irregularis* is responsible for a loss of biodiversity through predation. *Boiga irregualris* has had devastating effects particularly on avifauna such as the Guam rail and Guam flycatcher, small mammals including the Mariana fruit bat, and reptiles such as geckos and skinks. This paper will outline the negative impact that *Boiga irregularis* has had on the biodiversity of Guam, as well as the techniques being used to control the snakes population and discuss their effectiveness.

Biology of *Boiga irregularis*

A number of biological characteristics of *Boiga irregularis* contribute to its high population and aggressiveness on Guam. One of the characteristics that enables this snake to thrive is its size and shape. With a long slender body that can exceed 2.4 meters, used to constrict prey, and a large head, *Boiga irregularis* is better able to feed on a wide range of prey (Fritts & Scott 1985). This allows the snake to feed upon various bird species and their eggs, small mammals, lizards, domestic pets and poultry, and rodents. The snake's ability to prey on various animals throughout Guam has lead to its high population density and geographical range. Typically snake populations are dependent on prey populations because with ample prey available, more snakes are likely to survive to adulthood and reproduce, yet, according to Fritts (1988 p. 8), " *Boiga irregularis's* reproductive rate and juvenile survivorship are high, despite the decline in birds and rodents typically exploited as prey". The snake's high population density throughout the island is due to the fact that it reaches sexual maturity at about three years of age and lays approximately twelve eggs twice a year (Fritts 1988). *Boiga irregularis* is in the *Colubridae* family, which includes species that typically have lifespans of 10-15 years. With no natural predators, the rapid birth rate and survivorship creates a serious population problem. Also, like other reptiles, the mother abandons the eggs, yet the snakes are self-sufficient once hatched. Because *Boiga irregularis* is able to circumvent the limitation of feeding specialization and reproduce at a relatively high rate, it has taken hold of Guam.

Geography of *Boiga Irregularis* on the Island of Guam

Because of its biological characteristics, *Boiga irregualris's* invasion of Guam has spread at a rapid rate with devastating results. According to Savidge (1987), the snake was first reported in the savannas of south-central Guam in the early 1950's where it spread, and by the 1970's moved northward to forests, expanding its range at a rate of 1.6 km/yr. Although *Boiga irregularis* is typically found in forests or

areas of brushy vegetation, it is not confined to these landscapes. The snakes are able to have a broad range because there are no natural predators to limit its dispersal. Feral pigs and cats occasionally prey on *Boiga irregularis*, however only have minimal effect on the snake population (Fritts 1988). The estimated population density of *Boiga irregualris* assuming 50 snakes/ hectare (recorded from trapping) there would be approximately 13,000 snakes per mile squared, due to its ability live in various habitats and lack of natural predators (Fritts 1988).

Effects of *Boiga Irregularis* on Guam Wildlife

Boiga irregularis's most significant impact on the loss of biodiversity on Guam is most evident in the islands decrease of avifauna. In the 1950's there was a decline in the number of forest birds in the mid-south part of the island, and by the 1960's there was extinction of the forest birds in the south-central part of the island, in the 1970's extinction of forest birds reached the northern portion, and in the 1980's, the extinction of forest birds reached the northernmost portions of the island (Birds of Guam 2000). Either bird populations were completely decimated or only small isolated patches were left in the northern tip of the island (Rodda et al. 1997).

Historically there are 102 species of birds found on Guam. Of those species, 72 are migrant (yet are native), 22 are native, and eight are introduced. Of the native species, five are endemic at the species or subspecies level (Enbring & Fritts 1988). Even before the introduction of snakes to Guam, 4 of the 22 native species became extinct, and with the arrival of *Boiga irregularis* natve birds were decimated within four decades, with the explosion of snakes outnumbering birds four to one (Fritts & Rodda 1998). The introducation of *Boiga irregularis* on Guam has resulted in population declines of native resident birds; of the 18 native species, half have been extirpated, six are almost gone, and three exist in only small numbers (Enbring & Fritts 1988). Smaller birds were the first to start disappearing because their size makes them easy prey, coupled with the fact that the birds have no defense against snakes to protect them from predation since there are no snakes naturally on Guam. Of the eight introduced species only three have been drastically reduced in number because of their defense mechanisms, including: size (too big for snakes to swallow), beaks (used in defense), and/or self-preservation instincts (Enbring & Fritts 1988).

Table 1: Guam birds that have been extirpated due to introduction of *Boiga irregularis*

Scientific Name	Common Name
Acrocephalus luscinia	Nightingale reed-warbler
Gallicoluma xanthomura	White-throated ground-dove
Halcyon cinnamonina	Micronesian kingfisher
Myiagra freycineti	Guam flycatcher
Myzomela cardinalis	Cardinal honeyeater
Ptilinopus roseicapilla	Marian fruit-dove
Rallus owstoni	Guam rail
Rhipidura rufifrons	Rufous fantail
Zosterops conspicillatusi	Bridled white-eye

The birds of Guam are not the only fauna that has been affected by the predation of *Boiga irregualris*, small mammals and reptiles have been affected, as well. As a result of *Boiga irregularis's* predation on native lizard species, five are extinct or scarcely found on the island (Fritts & Rodda 1988). Guam was also once home to three native bat species, but since the introduction of *Boiga irregularis*, two of the

three species have been extirpated, only the Marianas fruit bat (*Pteropus marianus*) remains (Fritts et al. 1997). Birds and lizards eat many insects in the tropical forests of Guam and help to keep those populations in check, but with the drastic decline in their populations, insect density will surge (Fritts 1988). Consequently diseases carried or spread by insects may also rise. Forest birds are also a vital part of seed dispersal for vegetation, and without the birds spreading seeds, the natural succession of the forest may also suffer.

Measures Taken To Control Snake

Since Guam is a U.S. Territory, many agencies, organizations, and researchers who are involved in the control measures of *Boiga irregularis* are from the United States. The goal of the U.S. Fish and Wildlife Service and Guam's Division of Aquatic and Wildlife Resources has been develop and implement strategies for protecting and recovering endangered bird and bat species on Guam using a variety of conservation techniques. Other Federal agencies including (U.S. Geological Survey, U.S. Department of Agriculture's Wildlife Services, U.S. Departments of the Navy and Air Force) as well as cooperators from universities, zoos, conservation organizations, and other island governments have also worked toward the effort of controlling *Boiga irregularis* populations and damaging effects (Fritts & Rodda 1998). The organization responsible for carrying out the control methods for on *Boiga irregularis* is the Aquatic Nuisance Species Task Force (ANS). Because the threat that Boiga irregularis poses, there was a cooperative program sanctioned by the U.S. Congress under the Nonindigenous Aquatic Nuissance Prevention and Control Act of 1990 seeking to limit the consequences of the snake outside its native territories (ANS Task Force 1996).

The population density is too high to ever hope for total eradication, so the goal is to control the specie in order to restore native fauna to their natural habitat, eradicate any new populations, prevent the spread of the snake to other Pacific islands, develop more effective and environmentally sound control, and learn more information about the snake (ANS Task Force 1996). Measures being researched to control the snake include, biological, chemical, and physical. Because the snake and its ecological ramifications are relatively new, much research still needs to be done in order, to effectively use best management on the control of *Boiga irregularis*.

Current Techniques Used to Control *Boiga Irregularis*

Physical approaches

There are a variety of techniques used to control *Boiga irregularis* on Guam. One of the main concerns is to stop any more snakes from invading the island. The airport and the Air and Naval Bases have high security checking any planes, ships, and cargo coming from other places, especially ones that may have *Boiga irregularis*. Checking for snakes not only occurs on airplanes and cargo coming into Guam, but also on planes that are leaving the island, so as not to spread the snake to any other islands. Airport officials use dogs trained to sniff out *Boiga irregularis*. The dogs are very important to the process because snakes can fit just about anywhere and therefore make it hard for humans to detect them. At Anderson Air Force Base, on the northern tip of Guam, Jack-Russell terriers have been used for four years to detect *Boiga irregularis* from outbound cargo. The cost-effectiveness of training the dogs and officials is questionable because of the low number of snakes being detected (Fritts & Rodda 1988). Apparently this method has helped reduce the snake population in the area surrounding the Air Force Base, allowing for increased populations of some bird species (Butler 1997).

Another method of controlling *Boiga irregularis* is hand capturing, especially around the airport. Its effectiveness is, however, limited. One reason for this lack of effectiveness is that airport officials need to

have the proper training to know how to detect snakes efficiently and how to handle the snake to avoid snake bites. In addition, *Boiga irregularis* is nocturnal, and daylight captures require sufficient knowledge on possible snake locations.

Trapping is currently one of the most effective methods for capturing snakes in small, confined areas (ANS Task Force 1996). The traps are cylindrical in shape with a funnel at each end that allows snakes to crawl inside, but not get back out. Since snakes rely on olfactory senses traps need to have some type of attractant, whether chemical or live bait. The traps work well for large, adult snakes, but are too big to hold smaller snakes. There are also new adhesive traps (typically used to capture rodents), which could be an alternative trapping method for *Boiga irregularis* (Fritts 1988).

Physical barriers are also being used to keep snakes from entering or leaving areas of concern. Electrical and solar powered barrier equipment is used to prevent the snake from climbing tree trunks, thus protecting crow nests. Non electrical barriers are designed out of metal mesh, masonry, or vinyl seawall (Perry et al. 1998). The barriers can be quite successful in protecting the Mariana Crow nests, but alone they do not make a significant difference on *Boiga irregularis* predation. The barriers are effective for most snakes, except extremely large ones that may be able to climb over the top.

Chemical approaches

Fumigation with methyl bromide is used in cargo containers to kill snakes that are stowaways in order to prevent them from infesting new sites (ANS Task Force 1996). Because methyl bromide may be destructive to the ozone layer, other chemicals are being researched for fumigation purposes including, sulfural fluoride, magnesium phosphide, and aluminum. These may prove to be better alternatives (Savarie & Bruggers 1999).

Biological approaches

Researchers are also working to develop toxins and/or diseases that are species specific to the brown tree snake. Researchers are trying to develop viruses that give snakes a fatal infection (Butler 1988). A *Boiga irregularis* parasite, such as helminth parasites, which could be an intestinal worm like trematodes may also have control potential (Tellford in Rodda et al. 1999). Although these parasites may be a technique to be explored, treatment needs to be species-specific, thus not defeating its purpose.

There are many other techniques used to control the brown tree snakes on a small scale in Guam which include lighting to repel snakes (since they are nocturnal), habitat modification (reducing hiding places for snakes), manipulation of prey available, chemical attractants, and reproductive inhibition (ANS Task Force 1996).

Education of Guam's residents also plays a large part in controlling snake populations on Guam. Residents need to be informed of how to eradicate snakes they may find on their property and how they can eliminate snake attractants around and in their homes, like small pets outside and possible hiding places for snakes during daylight hours.

Reintroduction Efforts for Native Avifauna

Boiga irregularis populations need to be controlled in Guam before any reintroduction efforts of aviafauna have the possibility of success. As of the year 2000, the snake population is not under control on Guam, however there are small-scale efforts where native birds, like the Guam rail, are being bred in captivity to be released back into their native habitat. In September 1997, the Division of Aquatic

Wildlife Resources (DAWR) adopted both tools for the first large-scale operation to deplete the snake population in a 60-acre plot (known as Area 50) containing mixed native habitats. This was done by sealing the study area with snake barriers to keep snakes from entering. In November 1998, DAWR released sixteen captive reared Guam rails into Area 50, where today they have proved to be successful and safe from snake predation (Brock & Beauprez 2000). The previous example is just the beginning successful restoration efforts, if Guam can have several large-scale sites that are managed against *Boiga irregularis* and reintroduce populations of rails that are successful, measures can be taken to start reintroducing other species of native birds and other wildlife.

Recommendations

The key to the restoration process of Guam's fauna is to restrict the impacts of snake predation by drastically reducing the number of snakes on Guam. An exact number of a manageable snake population for the island is, cannot be given because the island naturally never had snakes. The question then is how many snakes the fauna of Guam can tolerate before significant problems arise. Although it is clear that there are too many snakes to achieve total eradication, there is hope of discovering new techniques and improving existing methods in controlling snake populations and restricting them to special areas. Even with improved techniques for snake control, the best management would include multiple methods. Relying on one technique may only target a small percentage of the snake population, therefore ignoring other populations. It is also important that managing *Boiga irregularis* occur on a large scale, focus has been on areas of special concern, but to restore the faunal populations, focus needs to be on the island as a whole. The agencies responsible for the control of *Boiga irregualris* populations need to integrate an intensive snake management plan that will take effect immediately. The plan should consist of all techniques necessary to drastically reduce *Boiga irregulais* populations before the damage is irreversible. The problem needs to be amended while restoration efforts are still feasible and cost effective for Guam.

Guam's first-hand experience with an exotic invasive species may prove to help other islands in the future. The methods and techniques used on Guam may help other islands with possible pest problems or may help to educate islands of the potential disaster an invasive non-native organism brings to an ecosystem. By using Guam as an educational tool of what can happen to an ecosystem, it may promote more careful thought in trade from country to country and in the ramifications of not taking precautionary methods. To properly control *Boiga irregularis* and develop best management practictes, there needs to be an increase of $4 million dollars a year in Federal spending, along with a shift from research to the actual implementation of programs as effective control methods are developed (ANS Task Force 1996).

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