# Invasions of the Brown Tree Snake

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Around 1950, populations of the brown tree snake (*Boiga irregularis*) were introduced on Guam, a previously snake-free island. This introduction was the result of post-World War II traffic carrying military materials from the South Pacific region (Savidge 1987; Rodda et al. 1992). It resulted in major ecological changes and the loss of several bird and lizard species from the island starting in the 1970's and extending to the late 1980's. The severity of ecological damages resulting from this introduced snake may have been increased by the presence of other nonindigenous species, which served as alternative prey as native species declined.

The brown tree snake dispersed throughout Guam in the 1950's, 1960's, and 1970's, reaching high populations that resulted in devastating levels of predation on most native and introduced vertebrates (Savidge 1987; Engbring and Fritts 1988; Rodda et al. 1992). At the peak of the snake's irruption on Guam, densities probably exceeded 100 snakes/ha (40 snakes/acre), but following depletion of many of Guam's birds and mammals, snake densities appear to have fallen to 20-50 snakes/ha (8-20 snakes/acre; Rodda et al. 1992).

Brown tree snake (*Boiga irregularis*). Courtesy G.H. Rodda

In the face of the loss of native forest birds and drastic reductions in other bird, mammal, and reptile species, the snake subsisted on smaller lizard prey and on introduced species, including lizards (*Hemidactylus frenatus* and *Carlia* cf. *fusca*), domestic poultry and cage birds, rodents (*Rattus* spp. and *Mus musculus*), house shrews (*Suncus murinus*), Eurasian tree sparrows (*Passer montanus*), and Javanese turtle doves (*Streptopelia bitorquata*). Thus, the reduction of snake densities that might have been expected after the loss of native prey species was limited because the snake could subsist on alternative introduced prey.

## Species Lost from Guam

Since the arrival of the snake on Guam, the island has lost most of its indigenous forest vertebrates (Fig. 1). Too few baseline data are available to unequivocally determine the degree to which the snake is responsible for these losses, but several kinds of evidence create a strong case for the snake's role in the extirpation of many bird species (Savidge 1987, 1988; Conry 1988; Engbring and Fritts 1988) and several lizard species (Rodda et al. 1991). Additionally, some evidence exists that the snake played a role in the disappearance and decline of Guam's native mammals, three bat species (Wiles 1987), but no direct information is available for the two bat species that disappeared before 1980. The evidence clearly shows, however, that Guam has experienced a remarkably complete loss of its vertebrate fauna.

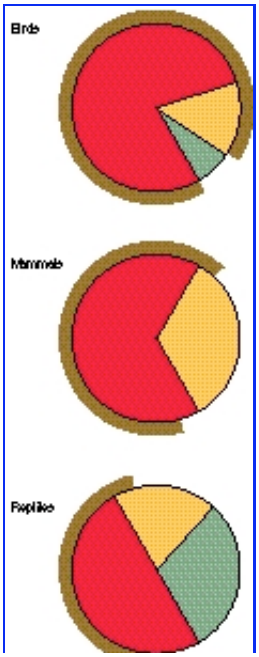


**Fig. 1.** Status in 1993 of Guam's native forest vertebrates (those present in 1950) with estimates of the degree to which decline was due to the introduction of the brown tree snake.

Even with all of the vertebrates at risk from the snake, the pattern of species' losses has followed a size gradient that is consistent with the snake's dietary habits (Engbring and Fritts 1988; Fritts 1988). Small birds, small mammals, and medium-sized lizards disappeared first and seem to have been most heavily affected. Contrary to what might have been expected, the most abundant bird species were affected first. We cannot determine if the abundance of the prey led to more effective search images for the snakes or if the ecological characteristics of the species and the habitats occupied contributed to this prey difference. The surviving native species and those that lasted the longest in the wild all exhibited extreme sizes (i.e., larger or smaller than those most affected) or some other trait that has minimized their vulnerability to snake predation.

Examples of these traits include large size: Mariana flying fox (*Pteropus mariannus*), Marianas crow (*Corvus kubaryi*), and Indian monitor lizard (*Varanus indicus*); urban dwelling: Micronesian starling (*Aplonis opaca*), mourning gecko (*Lepidodactylus lugubris*), and stump-toed gecko (*Gehyra mutilata*); cavity nesting: Micronesian starling and Micronesian kingfisher (*Halcyon cinnamomina*); cave ceiling roosting: gray swiftlet (*Aerodramus vanikorensis*); and extremely small size: mourning gecko and Marianas blue-tailed skink (*Emoia caeruleocauda*). All surviving endotherm populations (birds and mammals) consist of fewer than 1,000 individuals, and long-term population viabilities are in doubt for most of these groups on Guam.

Small lizards are much more numerous and have better long-term prospects even though evidence exists of localized extinctions caused by temporary surges in snake populations. The big tree gecko (*Gehyra oceanica*) has virtually disappeared since 1985, but its smaller congener (species in the same genus), the stump-toed gecko, persists in forested habitats in low numbers (Rodda et al. 1991). Some small introduced lizard species (mourning gecko, common house gecko, *Hemidactylus frenatus*, and brown four-fingered skink, *Carlia* cf. *fusca*) have expanded into new habitats in the absence of other species; they therefore maintain larger population levels on Guam even though they experience heavy predation by snakes.

The relative abundance of the Marianas blue-tailed skink has dropped markedly as the brown four-fingered skink increased after its arrival in Guam in the early 1950's (Fig. 2). Effects of predation by the snake and interactions between introduced lizards are evident in the relative abundances of lizard families, with the primarily arboreal gekkonids declining while the primarily terrestrial and more predation-resistant skinks have increased. Even introduced rodents and shrews show declines due to predation by snakes; trapping success for rodents and shrews was significantly reduced in 1984-85 compared to that of 1962-64 (Savidge 1987).

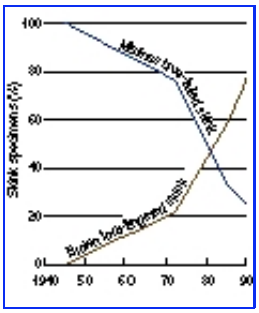


**Fig. 2.** Changes in the proportions of specimens of two common skinks in museum collections from Guam in four samples spanning 1945-90: Marianas blue-tailed skink (*Emoia caeruleocauda*) and brown four-fingered skink (*Carlia* cf. *fusca*).

## Risks of Dispersal from Guam

The many brown tree snakes on Guam make it probable that they may disperse as passive stowaways in ship and air traffic to other islands and the U.S. mainland (Fritts 1987, 1988; McCoid and Stinson 1991). To date, stowaway brown tree snakes have arrived in the northern Marianas Islands (Saipan, Rota, and Tinian); Marshall Islands (Kwajalein Atoll); Cocos Island near Guam; Okinawa; Diego Garcia in the Indian Ocean; Oahu Island, Hawaii; and Corpus Christi, Texas (Fritts 1988; unpublished manuscript). Verified and probable sightings of brown

tree snakes span 1949-94 and show that dispersal of the brown tree snake is not uncommon. The apparent surge in the 1990's probably reflects better reporting of stowaway incidents rather than increased dispersal.

## Risks of Damages from Further Colonizations

The islands adjacent to Guam are the northern Marianas, which have vertebrate faunas that are similar to Guam's, including some of the same introduced species. Like Guam, the northern Marianas have no native snakes. Thus, prey bases similar to those on Guam and capable of supporting high population levels of brown tree snakes exist in the northern Marianas, and species losses can be anticipated if the snake becomes established. For example, of 27 native resident bird species on the main islands of the northern Marianas (Saipan, Tinian, and Rota), 20 are shared with the original fauna of Guam and an additional 7 species are closely related to birds known from Guam. Guam and the northern Marianas also share five introduced bird species (Engbring et al. 1986). Six species of birds are federally listed as endangered or threatened in the northern Marianas, and all of these are conspecific (of or relating to the same species) or closely related to birds that have disappeared from Guam or declined significantly there (Engbring and Ramsey 1984; U.S. Department of the Interior 1990). Of 20 species of terrestrial amphibians and reptiles presently or formerly known from Guam and Cocos Island, 15 are shared with the northern Marianas, 8 native and 7 introduced (Rodda et al. 1991). Thus, the northern Marianas not only share the ecological vulnerabilities that led to mass extirpations on Guam, but also the bulk of the remaining habitat for Marianas' native species is on islands that have received stowaway snakes from Guam.

Hawaii suffered major losses in its vertebrate fauna after the arrival of the Polynesians and again after contact with Europeans. The state originally had 59 passerine bird species, but only 38 survived into historical times. Fifty species of passerines have been introduced in Hawaii, and those birds make up most of the land birds present today. At least 30 species of birds native to Hawaii are federally listed as threatened or endangered. One bird species native to Guam, the gray swiftlet, is established on Oahu (Moulton and Pimm 1986). Of the 14 reptile species present in Hawaii (all introduced), 8 are known as native or introduced species on Guam. Many of these introduced species are locally abundant and attain high population levels in Hawaii. All these factors show how capable the brown tree snake is in exploiting elements of the native and introduced fauna of Hawaii and in attaining high population levels in Hawaii and on other Pacific islands on which it may become established.

The effects of the brown tree snake extend beyond ecological damages; the snakes frequently climb on electrical transmission lines causing faults and disrupting electrical supplies, enter urban and residential areas where they consume poultry and pets, and bite humans causing trauma and serious health risks for small children (Fritts 1988).

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