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EFFECT OF TYPHOONS ON THE LIZARD COMMUNITY OF A SHELF ATOLL

BY

MICHAEL JAMES MCCOID

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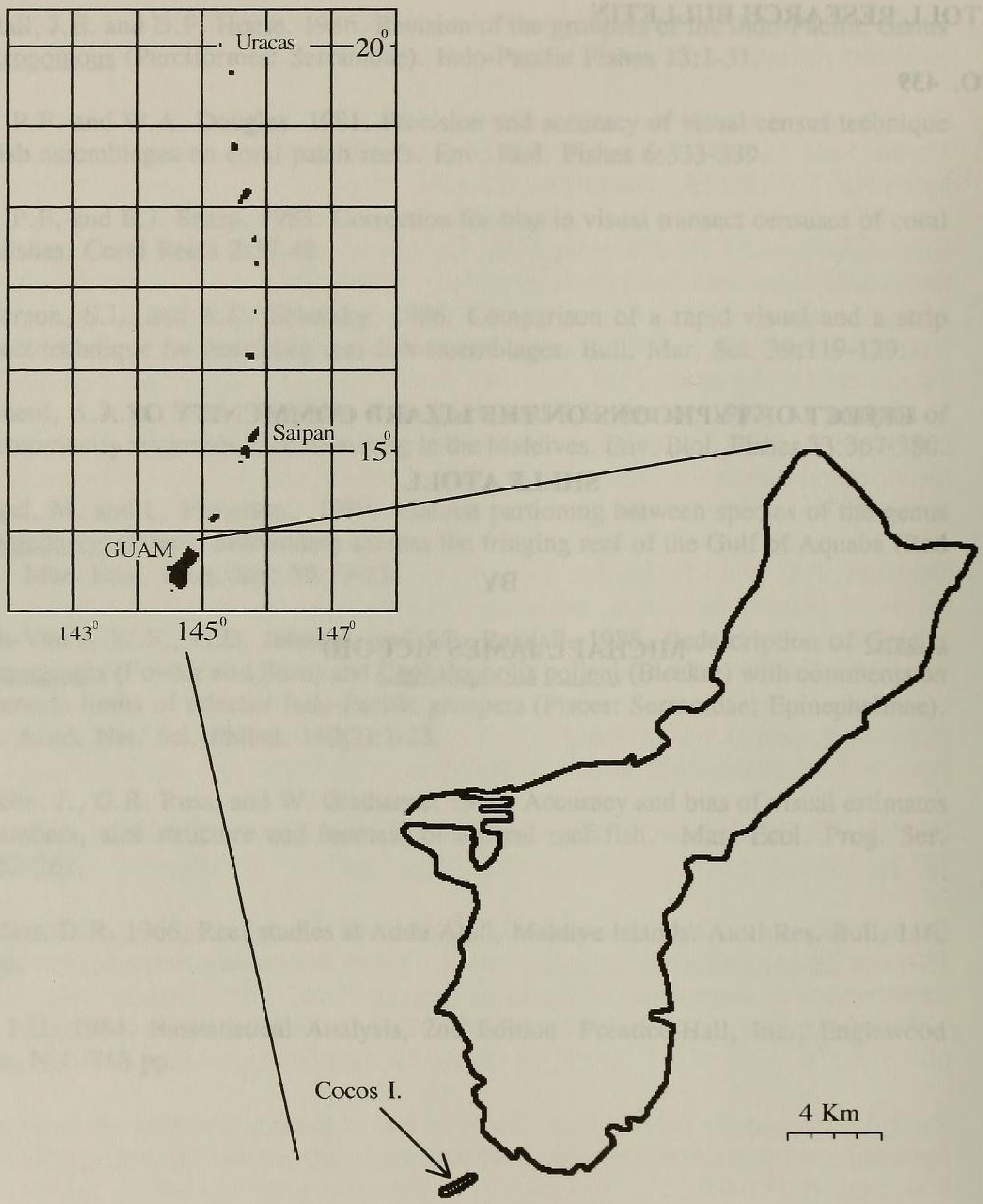

Figure 1. Map of the Mariana archipelago with the location of the study site.

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ABSTRACT

Two major typhoons hit the southern Mariana Islands within an 11 month span and provided a unique, unplanned opportunity to investigate storm influences on the herpetofauna of an atoll. Habitat specialists (*Emoia atrocostata* and *Cryptoblepharus poecilopleurus*) endured the largest population declines because of habitat destruction. All other species, particularly scincids, suffered less drastic population declines. The highest population declines for all species occurred on the developed (resort) end of the island, suggesting that removal and restructuring of typhoon-adapted vegetation allowed complete overwash and local extirpations. Cumulative effects of typhoons suggest a resilience to storm influences by atoll-dwelling reptiles.

The Mariana Islands comprise an archipelago of volcanic origin oriented north-south roughly equidistant between New Guinea and Japan. There are 15 major islands, with the northernmost (Farallon de Pajaros = Uracas) located at approximately 20°N, 145°E and the southernmost (Guam) at 13°N, 145°E (Fig. 1). Two km south of Guam, situated on the southern portion of a coral lagoon, is Cocos (Dano) Island. This atoll has a maximum elevation of 2 m and is approximately 100 m by 2 km. As of September 1992, forest vegetation on Cocos Island was dominated by *Cocos nucifera* (Coconut Palm), *Hernandia sonora* (no common name) and *Casuarina equisetifolia* (Australian Pine). Understory vegetation in the forest was dominated by *Carica papaya* (Papaya) with ground cover dominated by unidentified grasses and *Ipomoea pes-caprae* (Railroad Vine). Bordering the surf / tidal splash zone on the windward side of the atoll were dense thickets of *Pemphis acidula* (no common name). Vegetation on the developed (resort) northeastern 1/3 end of the atoll was dominated by *C. equisetifolia*, *C. nucifera*, and ornamental trees and shrubs. An historical record detailing vegetation was provided by Neubauer and Neubauer (1981). The atoll has undergone substantial changes during the past half-century including the development of a coconut plantation prior to WWII, construction of a U. S. military installation (formerly occupying approximately 1/4 of the island), two resorts (occupying a total of 1/2 the island; the present resort occupies only 1/3 the atoll), and at least three typhoons since 1949 that overwashed the island (Neubauer and Neubauer, 1981; per. obs.). Only about 1/3 of the island remains as atoll forest, albeit regenerated.

The climate of the southern Marianas is tropical with annual diurnal temperatures ranging between 22° and 31°C (Anon., 1990). Rainfall is seasonal (Anon., 1990) with

[1]Division of Aquatic and Wildlife Resources, P. O. Box 2950, Agana, Guam 96910, USA.

[2]Present Address: Caesar Kleberg Wildlife Research Institute, Texas A&M University, Kingsville, Texas 78363, USA.

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most occurring between June and December. Typhoons in the western Pacific are common and have been recorded on Guam in most months of the year (Myers, 1991). The typhoon season on Guam is between June and December.

Information on the effects of typhoons on the fauna of atolls is minimal; Jackson (1967) reported that insects and vertebrates persist despite catastrophic impacts and that lizards "somehow have found sufficient protection". Damage to and recovery of vegetation is better documented, with estimates of as long as ten years for a marked recovery (Wiens, 1962). In this unplanned study, I document changes in the herpetofauna of Cocos Island after the cumulative effects of two major typhoons.

While typhoons are a yearly event in the Mariana Islands, two storms of severe magnitude recently hit Guam within an 11 month span. Typhoon Russ hit Guam in December 1990 and Typhoon Yuri in November 1991. Minimum sustained wind speeds to attain classification as typhoons are the same as hurricanes (>74 MPH = 119 KPH) but these storms had sustained wind speeds recorded at 175 MPH (281 KPH). Along southeastern exposures (including Cocos Island), the direction that typhoons usually approach Guam, maximum estimated wave heights were 9 m. Damage caused by high winds and waves, in both typhoons, were substantial on Guam and catastrophic on Cocos Island. Typhoon Russ totally overwashed the atoll, defoliated all broadleaf vegetation, and downed an unknown, but large number of trees, particularly *C. equisetifolia* along the windward side of the island. Typhoon Yuri inflicted similar damage including loss of a substantial portion of the remaining *C. equisetifolia* on the windward side of the atoll. An estimated 40-60% of *C. equisetifolia* on Cocos Island were cumulatively lost during the typhoons. Another cumulative overt vegetation change observed was the virtual elimination of the *P. acidula* thickets bordering the high energy zone on the windward side of the atoll. An estimated 95% of the thickets were destroyed by Typhoon Yuri. Between typhoons, dominant forest vegetation releafed, seeded, and a dense understory of *C. papaya* and *C. nucifera* developed. Also during this period, the remaining *P. acidula* thickets releafed. Due to Typhoon Yuri, the papaya and coconut palm understory was destroyed and tremendous amounts of debris from the resort were strewn throughout the forest. The dominant understory vegetation that emerged after the second storm was *I. pes-caprae*.

The herpetofauna of the Mariana Islands has been characterized as depauperate (Rodda, et al. 1991) consisting of a pre-western contact terrestrial reptile fauna of 13 species (McCoid, 1993). Ten of these species occur on Cocos Island (*Gehyra mutilata, G. oceanica, Lepidodactylus lugubris, Perochirus ateles, Cryptoblepharus poecilopleurus, Emoia cyanura, E. caeruleocauda, E. atrocostata, E. slevini*, and *Varanus indicus*) and an additional two species (*Hemidactylus frenatus* and *Carlia* cf. *fusca*), both introduced to the Marianas (McCoid, 1993), are established on Cocos Island. At present, Cocos Island possesses the most diverse reptile fauna (12 species) of any island in the Mariana archipelago. Declines in the herpetofauna of the Mariana Islands were discussed by Rodda, et al. (1991) but most species formerly found on Guam still occur on Cocos Island. Although there are no native amphibians on the Mariana Islands, *Bufo marinus* is established on Guam and Cocos Island.

The pre-typhoon reptile fauna on Cocos Island was not uniformly distributed in all habitats. The gekkonids *G. oceanica, H. frenatus*, and *P. ateles*, were found in both developed and forested areas (McCoid and Hensley, 1994), but differences in densities between these habitats were not investigated. *Gehyra mutilata* and *L. lugubris*, however, were far more common in the relatively undisturbed forested areas; I encountered only two *L. lugubris* in the resort area during nocturnal surveys and no *G. mutilata* (G. Rodda, pers. com., recorded these species in the forest). Scincids were also not evenly distributed in all habitats. *Carlia* cf. *fusca*, perhaps introduced as recently as the late 1980's to Cocos Island (T. Fritts, pers. com.) was found only at a boat landing and public park on the western end of Cocos and at the resort on the eastern end on the island in early 1989. By mid-1990, the species was observed in intervening habitats on Cocos Island. By early 1991 (see below), the species was abundant in all areas. *Cryptoblepharus poecilopleurus* was most conspicuous on the windward (east) side of the island where it commonly occurred on tree trunks in *C. equisetifolia* groves (Hensley and McCoid, 1994). Generally, any tree with a trunk diameter > 2.5 cm had at least one resident *C. poecilopleurus*. *Emoia cyanura* was found in both resort and forest areas but was associated with sunlit, open habitat. Expansive areas of dense undergrowth harbored few individuals. *Emoia caeruleocauda* favored heavily shaded areas and was common in the forest and resort, but was occasionally found in open areas. *Emoia atrocostata* was restricted to the high energy *P. acidula* zone (total habitat 4 ha) on the windward side of Cocos Island. *Emoia slevini* only occurred in forest (total habitat 9 ha) (McCoid, et al. 1995).

Qualitative surveys of the herpetofauna of Cocos Island were initiated in April 1989 and initially consisted of nocturnal surveys for gekkonids, diurnal surveys for arboreal scincids (both time-constrained surveys), and diurnal surveys for terrestrial scincids using rubberbands. Time-constrained surveys (N = 5, between April 1989 and December 1991) for *C. poecilopleurus* were limited from 15 to 30 min during which all lizards seen while walking through *C. equisetifolia* groves were recorded. Time-constrained surveys for gekkonids were conducted on the resort and lasted between 1.5 and 2 h during which all lizards encountered along a predetermined route were either collected or recorded. In September 1990, sticky traps (see Rodda, et al. 1993), which provide a mechanism to estimate relative abundance, were first employed to sample terrestrial reptile faunas in forested, resort, and beach areas of Cocos Island. Traps (10-80) were placed at five m intervals and checked every 15 min at which time any lizards captured were removed. Generally, sticky trapping spanned the time between 0700 and 1200 h. Rubber-banding was only rarely employed after September 1990. After the December 1990 typhoon, nocturnal surveys were discontinued (see below) and only arboreal diurnal and sticky trapping survey techniques were used.

Pre-typhoon Russ herpetological surveys of gekkonids in the resort yielded a qualitative estimated community structure (expressed as percentage of total number of lizards) of *P. ateles* (4.5 %), *G. oceanica* (6.2 %), *L. lugubris* (0.6 %), and *H. frenatus* (88.8%) (N = 315 lizards in 30 person-hours survey effort). Unfortunately, the survey route for gekkonids was completely destroyed by the cumulative effects of both typhoons. This was exacerbated by the clean-up efforts of the resort corporation in which remaining debris was removed. Thus, no comparable post-typhoon data could be generated.

Surveys immediately after Typhoon Yuri yielded no lizards of any species on the approximately 1/3 of the island occupied by the resort. This portion of the island was subjected to the most intense vegetation / structural loss from typhoons. Although gekkonids were common in the resort prior to the typhoons, population densities of gekkonids in the relatively unsurveyed forest sections of Cocos Island are unknown; I can only assume that a sizable fraction of the gekkonids on Cocos Island were lost because of typhoons. Post-Typhoon Yuri diurnal surveys in forest areas targeting gekkonids revealed the persistence of all previously recorded species on Cocos Island.

Pre-typhoon sticky trapping surveys for *E. atrocostata* yielded a Catch-Per-Unit-Effort (CPUE) of 0.304 lizards/trap hr (N = 51 lizards, trap hrs = 168). Trap-hours are defined as one trap set for one hr = one trap hr. CPUE's are the number of lizards captured/trap hr. Post-typhoon surveys yielded a CPUE of 0.022 (N = 2 lizards, trap hrs = 90). This is a decline of an order of magnitude in catch rates and suggests that the population on Cocos Island declined by over 90% due to cumulative typhoon effects.

The remaining *Emoia* species (*cyanura*, *caeruleocauda*, and *slevini*) and *C.* cf. *fusca* can be discussed as a group as no changes in ranking of species collected (see below) in the forest area were noted after or between typhoons. These four species were initially sampled in forest using rubber-banding in early 1989 through late 1990 and sticky trapping in September 1990. Initial levels of efforts were low (total trap hrs = 22) or not quantifiable (rubber-banding). Numbers of lizards collected, ranked in terms of most to least abundant, indicated that *C.* cf. *fusca* was the most common followed by *E. caeruleocauda*, *E. cyanura*, and *E. slevini*. All sticky trapping surveys in the forest after December 1990 (N = 5) were conducted along the same transects and yielded the same ranking in abundance as above. Trapping (N = 1400 trap hrs) was conducted in January, June, October, and December 1991, and September 1992. Two surveys (January 1991 and December 1991) were conducted within two weeks after typhoons. Percentage composition for each of the species (grand total = 365 skinks) in the five forest surveys ranged between 57.6 and 68.9 for *C.* cf. *fusca*, 20.7 and 30.3 for *E. caeruleocauda*, 2.6 and 12.9 for *E. cyanura*, and 0.0 and 2.6 for *E. slevini*. Changes in percentage compositions between surveys were tested using a R X C test of independence with a William's correction and were not significantly different ($\chi^2_{calc,12,.05} = 9.197$). This suggests that responses of individual species to typhoon effects were not statistically different. Similarly, CPUE's for all surveys were within the same order of magnitude (range 0.171 - 0.475) indicating that the cumulative effects of the typhoons did not dramatically decrease catch-rates of forest-dwelling scincids. Since at least 1/3 of the island was devoid of any lizards after Typhoon Yuri (see above), it is safe to assume that total population declines were greater for *E. cyanura*, *E. caeruleocauda*, and *C.* cf. *fusca* than for *E. slevini*, which occurred only in forest.

Numbers of *C. poecilopleurus* were gauged by sightings per min (range 0.33 - 1.1). These sighting data, including both pre- and post-typhoon observations, are within the same order of magnitude suggesting that typhoon effects were minimal on survivorship of *C. poecilopleurus*. Importantly though, post-typhoon observations were made on existing trees and since sighting rates after typhoons did not increase on these trees, perhaps indicating emigration of surviving lizards from felled trees to existing trees, it is assumed that if a tree was lost during a typhoon, the resident lizards were also lost.

The ability of a herpetofauna to persist on an atoll after substantial environmental perturbations are also highlighted by observations on two species not directly surveyed in this report. *Varanus indicus,* although found on Guam, was probably introduced to Cocos Island in the late 1980's (pers. obs.) and managed to persist through two major typhoons. By December 1991, in addition to a number (3 - 5) of 200 to 450 mm snout-vent length (SVL) lizards, a small (ca. 100 mm SVL) individual had been observed on Cocos Island. These observations suggest that successful reproduction had occurred and monitor lizards had survived the typhoons. *Bufo marinus* was probably introduced to Cocos Island in 1989 and successful reproduction (large numbers of tadpoles in rain pools) was observed in September 1989. In September 1992, after both typhoons, two adult (ca. 80 mm SVL) *B. marinus* were observed in a freshwater pool.

Observations of the herpetofauna on Cocos Island after typhoons suggest a resilience to environmental perturbations. Terrestrial forest-dwelling scincid populations appeared to persist relatively unscathed despite substantial typhoon impacts. Habitat specialists (*E. atrocostata* and *C. poecilopleurus*) were more susceptible to population declines due to habitat destruction. All gekkonid species also persisted after the substantial effects of the typhoons. Besides *C. poecilopleurus* and *E. atrocostata*, the largest localized population declines of other species are associated with the developed (resort) section of the atoll. This may be related horticultural / architectural practices that restructure typhoon adapted vegetation allowing complete overwash and loss of most structures, soil, and sand during severe storms.

Considering the absence of all lizards on the resort 1/3 of the atoll, a substantial fraction of the lizard population was lost because of the cumulative effects of typhoons. Habitat specialists *E. atrocostata* and *C. poecilopleurus* probably suffered much greater population declines, which is related to susceptibility of these habitats to typhoon damage. Despite that, the data suggest that relatively undisturbed atolls will tend to retain herpetofaunal components despite substantial typhoon influences.

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