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Abstract—Detector dog inspection of outbound cargo is one of several control methods applied to deter brown tree snake dispersal from Guam. In the two and a half months following the passage of Supertyphoon Paka over Guam, an increase in brown tree snake discoveries during detector dog inspections was observed. We report here on the circumstances of those discoveries and their management implications.

Introduction

The brown tree snake (*Boiga irregularis*) was accidentally brought to Guam after World War II and has established extraordinary population densities throughout the island. It is a worst-case example of the effects that an introduced predator can have on a native insular fauna (Savidge 1987). The arboreal snake encountered abundant prey on Guam, most with few predatory defenses. Predation by the snake led to the rapid demise of Guam's native birds, lizards, and bats. Currently, three of 12 species of native forest birds survive in the wild, with one of those on the verge of extinction (Savidge 1987, Wiles et al. 1995). Recruitment in the Guam population of Mariana fruit bats (*Pteropus mariannus*), already threatened by over-hunting, has been suppressed by snake predation (Wiles et al. 1995) In addition, many of Guam's 11 native lizards have been impacted by snake predation (Rodda & Fritts 1992).

Guam has also suffered economic and social consequences from brown tree snake introduction. Snakes have become agricultural pests through depredations on poultry and other small domesticated animals (Fritts & McCoid 1991). Their climbing on utility poles and wires causes frequent power failures, which result in millions of dollars of damaged equipment, lost productivity, and repair costs (Fritts et al. 1987). Furthermore, the brown tree snake is mildly venomous and readily enters buildings, where it may present a health threat to small children (Fritts et al. 1990).

Brown tree snakes are opportunistic feeders that consume a highly varied diet (Savidge 1988, Rodda et al. 1997, Linnell et al. 1997) and can survive in close proximity to human development. They are agile climbers that seek refuge from heat and light during daylight, occasionally in cargo, shipping containers and transport vessels. These characteristics, coupled with Guam's position as a focal point for commercial and military shipments of cargo and passengers throughout the western Pacific and Hawaii, present a significant threat for snake dispersal. Brown tree snake sightings have been documented on many Pacific islands, with an incipient population speculated to exist on Saipan in the Commonwealth of the Northern Mariana Islands (McCoid et al. 1994).

Inspection of outbound cargo and transport vessels using detector dogs is one of several control methods applied in an integrated program aimed at deterring the spread of brown tree snakes from Guam. Population reduction efforts using specially designed snake traps and hand capture have created snake-reduced zones around port and cargo staging areas (Engeman et al. 1998b). Re-invasion of forested plots in the fragmented habitat characteristic of air and sea ports appears to be slow (Engeman et al. 1998a, 1998d, Engeman & Linnell 1998). Snake removal efforts have reduced snake invasion of cargo, with an accompanying decrease in the rates at which detector dogs discover snakes during cargo inspections (Engeman et al. 1998a, 1998b, 1998c, 1998e). However, since some snakes circumvent other removal efforts, detector dog inspections of outbound cargo remain necessary.

On 16 December 1997, Supertyphoon Paka (Paka) struck Guam, causing substantial damage to buildings, infrastructure, and forest habitat. While it is unknown what effects the storm had on brown tree snake populations and behavior, an increase in snake discoveries by detector dogs was observed following Paka. We report here on the circumstances of these discoveries and their management implications.

Inspection Procedures

Outbound cargo and cargo vessels on Guam are subjected to searches by snake detector dog teams of the United States Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services (WS). Each team is comprised of a handler and a unique detector dog (Jack Russell terrier). Cargo inspections are prioritized based on the risk of snake incursion in cargo and the probability of snake colonization at a receiving location (Vice et al. 1999). Table 1 provides an overview of the general locations, materials, and frequency of inspections using dogs.

Records of all dog search activities are maintained by WS on Guam. When a brown tree snake is located by a dog team, the handler completes a written report that includes the identities of the handler and the dog, the date, site, time of day, a detailed description of the circumstances and location of the snake, and potential destinations for the outbound snake.

Table 1. An overview of locations, types, and frequencies of brown tree snake inspections conducted with detector dog teams on Guam. AAFB = Andersen Air Force Base, AMSS = Air Mobility Support Squadron, FISC = Fleet Industrial and Supply Center, COMNAVMAR = Commander Navy Marianas, TMO = Traffic Management Operations, WPIA = Won Pat International Airport.

Location	Frequency	Cargo Inspection Description
AAFB	Daily	Outbound cargo and the cargo staging areas at the AMSS and the TMO warehouses. Outbound aircraft, when an aircraft headed for a high risk destination is parked over night.
Harmon	Daily	Outbound cargo and staging areas inside 14 industrial warehouses.
COMNAVMAR	Daily	Cargo and staging areas at FISC warehouse, vehicle lot, and dry dock wharf.
Kilo Wharf	As needed	Ordnance is inspected prior to loading ship.
Commercial Port	Daily	Outbound cargo and cargo staging areas at three warehouses.
Hotel Wharf	Daily	Break-bulk cargo is inspected prior to loading ship.
WPIA	Daily	Cargo and cargo staging areas, and commercial and private aircraft.
Military exercises	As occur	Dog teams are on 24 hour call to inspect cargo, staging areas, vehicles, transportation craft and personal gear associated with military exercises.
Military housing	Daily	All military installations and housing island wide.

Areas and frequency have increased as dog-teams have been added to the program.

Results and Discussion

In the two and a half months following Paka, four brown tree snakes were discovered during detector dog inspections. Table 2 summarizes the circumstances for each find. As with previous brown tree snakes found by detector dogs (Engeman et al. 1998c) these snakes posed considerable potential for dispersal from Guam. Prior to the find on December 31, 1998, the previous brown tree snake located during an inspection occurred in July 1996 (Engeman et al. 1998c). The four snake discoveries in the 10- week period following Paka represent a substantial increase in the rate of snake detections.

Several reasons may explain why a major typhoon led to increased snake discoveries during dog inspections. First, the massive destruction caused by the storm may have impacted brown tree snake food and habitat resources, influencing snake behavior in a manner that would bring snakes into contact with

Table 2. Summary of brown tree snake discoveries by detector dogs after Typhoon Paka. AAFB = Andersen Air Force Base, WPIA = Won Pat International Airport.

Date	Site	Specific Circumstances	Potential Destination(s)
31 Dec 1997	WPIA	In Continental cargo container	Honolulu, Hawaii
27 Feb 1998	AAFB	In cargo pallet	Travis AFB, California, with potential for Hickam AFB, Hawaii
28 Feb 1998	WPIA	Under Continental aircraft	Micronesia, Hawaii
28 Feb 1998	WPIA	Outside Northwest cargo area	Continental U. S.

cargo facilities. Second, relief materials entering Guam to assist with typhoon recovery may have contacted snake habitat. As recovery progressed, the departure of these relief materials may have presented increased opportunities for snake discoveries by detector dogs. In addition, the 17- month period from July 1996 to December 1997 saw considerable refinement in training and inspection procedures for the dog teams, with a concurrent increase in snake detection efficacy (Engeman et al. 1998b, 1998e). Given potential increases in the number of snakes entering outbound cargo after Paka, there was an increased likelihood that those snakes would be detected.

An increase in brown tree snake discoveries during cargo inspections after Paka suggests some important management considerations. Events that increase cargo flow, such as large military exercises or responses to natural disasters, may increase the opportunity for snake dispersal. Extensive natural phenomenon that alter snake habitat on Guam may also promote brown tree snake entrance into Guam's cargo flow. In the aftermath following natural disasters, some brown tree snake control methods may be inoperable, increasing the threat of brown tree snake export. Paka damaged many snake traps, destroyed structures and vegetation where traps were placed, and destroyed perimeter fences on which nightly spotlight searches were conducted. However, detector dogs were available for outbound cargo inspections the day following the typhoon. Under such circumstances, the importance of detector dog searches are maximized.

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