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April 1998

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Engeman, Richard M.; Rodriguez, Danny V.; Linnell, Michael A.; and Pitzler, Mikel E., "A review of the case histories of the brown tree snakes (*Boiga irregularis*) located by detector dogs on Guam" (1998). *USDA National Wildlife Research Center - Staff Publications*. 634.

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## A review of the case histories of the brown tree snakes (*Boiga irregularis*) located by detector dogs on Guam

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Accepted 29 January 1998

### Abstract

Records of 34 brown tree snakes detected during dog inspections were examined to describe the situations in which snakes were found and to determine probable destinations had they successfully departed Guam. A key to the use of detector dogs for interdicting brown tree snake transport from Guam is that the snakes found are at high risk for export. Hawaii, followed by the Micronesian islands, were the most frequently identified potential destinations for the snakes located by dogs. Published by Elsevier Science Ltd.

### 1. Introduction

The brown tree snake, *Boiga irregularis*, is an exotic species that was inadvertently introduced to the island of Guam, probably in the 1940s (e.g., Fritts, 1988; Rodda et al., 1992). Since then, it has been responsible for the extirpation of, or substantial reductions in populations of Guam's forest birds (Savidge, 1987), fruit bats (Wiles, 1987a, 1987b; Wiles et al., 1995), and native lizard species (Rodda and Fritts, 1992). It has also become a problem for local poultry producers (Fritts and McCoid, 1991), electrical utilities (Fritts et al., 1987) and is a public health and safety risk (Fritts et al., 1990).

Guam's importance as a shipping hub in the Pacific, coupled with the fragility of other Pacific island ecosystems to which much of the out-going cargo flows, has made the potential spread of the brown tree snake from Guam a serious concern. Between 1949 and 1996, brown tree snakes have been recovered on Oahu in the state of Hawaii; Saipan, Tinian and Rota in the Commonwealth of the Northern Marianas (CNMI); Pohnpei in the Federated States of Micronesia (FSM); Kwajalein in the Marshall Islands; Diego Garcia Atoll in the Indian Ocean; Okinawa in the Ryukyu Islands of Japan; Cocos Island of Guam; Wake Island; south Texas (Fritts, 1987; McCoid and Stinson, 1991; McCoid et al., 1994 unpublished summary from workshop on Controlling the Brown Tree Snake and Preventing its Colonization of Micronesia). No documentation to date confirms that

brown tree snakes have established breeding populations at any of these locations, however a large number of sightings on Saipan have led to speculation that an incipient population exists there (McCoid et al., 1994).

Operational control and containment activities were initiated in 1993 on Guam at air and sea port facilities, and other areas of high risk, to curtail the dispersal of the snakes from Guam. Much of the control effort has been directed at the capture of brown tree snakes from the high risk areas by a variety of trapping strategies and during night searches of fence lines using spotlights. However, much of the cargo exported from Guam originates from areas of the island outside where snake removal efforts are applied. A large portion of the cargo flow from Guam has been defined and categorized according to the threat of dispersing brown tree snakes to vulnerable destinations (Linnell and Pitzler, 1996). Cargo destined for susceptible locations and the associated cargo holding facilities are subjected to searches for snakes using detector dogs. Long-term investigations are currently underway to examine the efficacy of the detector dogs for locating brown tree snakes in a variety of operational circumstances. As a preliminary to the eventual results from controlled trials, we report here on the case histories to date of the naturally occurring brown tree snakes located by the dogs and their most likely destinations had they successfully been transported from Guam.

### 2. Materials and methods

Cargo, cargo staging areas, and transport vessels identified as posing a risk for accidental introduction of a

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brown tree snake to a vulnerable location are subjected to searches by detector-dog teams of the USDA/APHIS/Animal Damage Control (ADC) operational staff on Guam. Each team is comprised of a handler and the unique detector-dog (Jack Russell terrier) assigned to that handler. Table 1 provides an overview of the general locations, materials and frequency of inspections using dogs. During an inspection, the dogs have the stamina to search for 40–60 min, depending on temperature and the physical difficulty of the search.

Records of dog search activities have been maintained by ADC on Guam and the records of all cases where brown tree snakes were located by the detector dog teams were examined for the present study. The data contained in the records included the specific dog and handler, the date, the time, the location searched and the details of exactly where the snake was found at that location. The records date from the initial use of the detector dogs in 1993. Based on where each snake was found and the cargo or vessel movements associated with that location at that time, we identified the most likely possible destinations for each snake had it successfully departed Guam.

### 3. Results

Table 2 summarizes the data for the 34 brown tree snakes located through August 1996 by detector dogs. The detail in Table 2 also provides an indication of the diversity of materials and ever-changing situations to which the detector dog teams are applied and in which brown tree snakes have been found during operational searches.

Some difficulty exists in relating where the snakes have been found (Table 2) to where dog team inspections currently take place (Table 1). In some cases, search sites have changed possession, such as the Naval Air Station which is no longer a military installation but is under the Guam Airport Authority at Won Pat International Airport. Also, there can be no clear distinction for categorizing a snake located during a military exercise and a snake located on a military base when the base is being used in a military exercise. Operationally, the increase in activity during an exercise results in increased use of dog teams for inspections. Other ambiguities exist between where snakes have been found and the categories for inspections in Table 1. We therefore do not attempt to

Table 1  
An overview of locations, types, and frequencies of brown tree snake inspections conducted with detector dog teams on Guam<sup>1</sup>

Location <sup>2,3</sup>	Frequency <sup>3</sup>	Inspection description <sup>2</sup>
AAFB warehouses	Daily	Outbound cargo and the cargo staging areas (indoors and outdoors) are inspected at the AMCC, TMO and HC-5 warehouses.
AAFB aircraft	By request	Cargo and aircraft are inspected when a plane has remained over night and a request is made for an inspection.
Harmon industrial	Daily	Outbound cargo and the staging area vicinity inside up to 7 warehouses.
NAVACTS warehouse	When ship loads	Cargo and staging areas of FISC warehouse are inspected as ship is loading, often requires multiple inspections per day.
NAVACTS Kilo Wharf	When ship loads	Ordnance is inspected prior to loading ship.
NAVACTS Polaris Point wharf	NA	Wharf area formerly was inspected, but discontinued because ships were using it for staging area, not transfer of cargo.
Apra Harbor Commercial Port	Daily	Inspections are made of outbound cargo and cargo staging areas at 2 warehouses, break-bulk cargo, and boats and barges that transport cargo.
Apra Harbor Hotel Wharf	Daily	Break-bulk cargo and boats and barges are inspected.
WPIA cargo	Daily	Cargo and cargo staging areas, inside and outside, are inspected for commercial airlines with destinations vulnerable to snake introduction. Commuter and private areas are not inspected at this time.
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	Goods in household moves are inspected the same day they are loaded for shipment off-island. Inspections occur at AAFB, AAFB-South, NCTAMS, NAVACTS, Nimitz Hill, Naval Hospital.
Civilian housing	Daily	Civilians under military contract, subject to moves by the military are inspected in the same fashion as military housing. Location can be anywhere on Guam.
Snake sightings	By request	Searches are sometimes conducted in housing to track a snake that had been sighted.

<sup>1</sup>Inspection sites as of August 1996, except for Polaris Point Wharf where inspections were discontinued.

<sup>2</sup>AAFB = Andersen Air Force Base, AMCC = Air Mobility Control Center, FISC = Fleet Industrial and Supply Center, HC-5 = helicopter squadron warehouse, NAVACTS = Naval Activities, NCTAMS = Naval Computer and Telecommunications Area Master Station, TMO = Traffic Management Operations, WPIA = Won Pat International Airport.

<sup>3</sup>Areas and frequency have increased as dog-teams have been added to the program.

Table 2

Summary of brown tree snakes found in inspections by detector dogs and their most likely destinations had they departed Guam.

Date	Where found <sup>1</sup>	Possible destination(s)
Nov 93	WPIA, outbound cargo area for Continental Air Micronesia	Micronesian islands, Hawaii, Pacific rim
Dec 93	WPIA, grass near Northwest Airlines maintenance vehicle	Saipan, Asia
Dec 93	NAS, pallets near Hanger 2	Hawaii, Pacific rim
Feb 94	NAVACTS, Kilo wharf pallets holding bombs	unknown
Mar 94	NAS, Naval Supply building engine storage container	Hawaii, mainland U.S.
Mar 94	WPIA, grass 10 m from aircraft of Continental Air Micronesia	Micronesian islands, Hawaii, Pacific rim
Mar 94	AAFB, 17 m from CH-46 rescue helicopter	Ships in Pacific
Apr 94	NAVACTS, wharf, under vehicle hood ready for shipment	Woodby Is, WA
Apr 94	NAS, grass 7 m from Hanger 2	Hawaii, ships in Pacific
Apr 94	WPIA, 25 m from cargo area of Continental Air Micronesia	Micronesian islands, Hawaii, Pacific rim
Jun 94	NAS, grass between Hangers 1, 2, 3	Hawaii, ships in Pacific
Jun 94	NAS, 2 snakes in cab of government pickup truck	Incidental find, no off-island potential
Jun 94	AAFB, pallets 7 m from Hanger 1 door	Pacific, Air Force destinations
Jul 94	AAFB, grass 50 m from cargo staging in Hanger 4	Pacific, Air Force destinations
Aug 94	WPIA, 75 m from cargo area of Continental Air Micronesia	Micronesian islands, Hawaii, Pacific rim
Aug 94	NAVACTS, 35 m from Polaris Point naval wharf area entrance	Pacific ports
Aug 94	NAVACTS, grassy area near Polaris Point naval wharf	Pacific ports
Sep 94	AAFB, housing area <sup>2</sup>	Assistance request, no off-island potential
Sep 94	AAFB, K-9 kennel area	Incidental find, no off-island potential
Oct 94	AAFB, housing area <sup>2</sup>	Assistance request, no off-island potential
Oct 94	NAVACTS, grassy area near Polaris Point naval wharf	Pacific ports
Oct 94	AAFB, tracked snake crossing road near Hanger 4 (cargo staging)	Pacific, Air Force destinations
Nov 94	AAFB, cargo container about to be loaded for shipment	Tinian
Jul 95	AAFB, Navy HC-5 warehouse doors	Hawaii, Pacific ports
Jul 95	AAFB, by Navy HC-5 warehouse	Hawaii, Pacific ports
Sep 95	AAFB, box in Navy HC-5 warehouse	Hawaii, Pacific ports
Sep 95	AAFB, at door Navy HC-5 warehouse	Hawaii, Pacific ports
Oct 95	AAFB, inside Navy HC-5 warehouse	Hawaii, Pacific ports
Oct 95	AAFB, inside Navy HC-5 warehouse	Hawaii, Pacific ports
Feb 96	AAFB, inside Navy HC-5 warehouse	Hawaii, Pacific ports
May 96	WPIA, 30 m from Northwest Airlines cargo area	Saipan, Asia
Jun 96	NAVACTS, snake tracked from FISC warehouse entrance to parked vehicle	Naval destinations worldwide
Jul 96	AAFB, housing area <sup>2</sup>	Assistance request, no off-island potential

<sup>1</sup>AAFB = Andersen Air Force Base, FISC = Fleet Industrial and Supply Center, HC-5 = helicopter squadron warehouse (scheduled for closure 8/96), NAS = Naval Air Station (Turned over to Guam Airport Authority in 1995), NAVACTS = Naval Activities, WPIA = Won Pat International Airport.

<sup>2</sup>The K-9 unit has responded to calls for assistance when brown tree snakes have been spotted around homes. However, searches of household goods prior to off-island moves form an important aspect of the canine program.

assign frequencies of snake discoveries to the categories in Table 1. We can describe the general situations in which snakes were found according to the potential for their export.

Of the snakes found, 4 were in outbound cargo or cargo containers, 6 were found indoors in cargo staging areas immediately accessible to cargo or the transport vessel and 18 were found in the areas immediately outside cargo staging areas. Twenty-one percent (7) of the snakes were found at the HC-5 warehouse on AAFB, a facility located adjacent to a favorable snake habitat. The functions of this warehouse were scheduled to be moved in August 1996 to a central, more developed area of AAFB. As a result, the associated activities should be less susceptible to snake intrusions.

Not all snakes were found as the result of inspection

of cargo or vessels awaiting departure from Guam. Three snakes were found by dogs in transit incidental to inspections and 3 others were found at the request of people housed on AAFB after a sighting of a snake in or around their homes.

It is impossible to determine with certainty the exact potential destination of all snakes detected because cargo storage areas, the cargo containers, and the vessels carrying the cargo often represent more than one potential destination. However, based on knowledge of cargo flows and the specifics of each case, we produced the most probable destinations in Table 2, if the snakes had been able to successfully depart Guam from the position in which they were detected. Thus, for many of the snakes found, more than one destination is listed in Table 2. Hawaii was the potential destination most frequently

identified (23 of the cases), followed in frequency by 17 cases that could, potentially, have gone to other islands in Micronesia. Because the commercial airlines and military air- and sea-craft travel throughout the Pacific (and the rest of the world), the dog teams are addressing the potential that exists for distributing brown tree snakes to distant areas.

#### 4. Discussion

Had the brown tree snakes discovered by the detector dogs managed to be exported, their most likely destinations would have been among the more vulnerable for colonization (Fritts, 1988). The most frequent possible destinations for the snakes detected by the dogs have been Hawaii and the Micronesian islands, however, the entire Pacific rim and mainland U.S. would be potential destinations due to the extensive transportation of cargo there from Guam.

A combination of factors ensured that the bulk of snakes discovered by the dog teams would be in position to travel to vulnerable destinations. Firstly, due to Guam's location, it is very likely that both military and commercial vessels that leave Guam will be destined for, or stop at, other vulnerable Pacific islands. Secondly, detector dog inspections, and control efforts in general, have been directed towards preventing brown tree snakes from becoming stowaways in cargo or vessels going to locations most susceptible to their introduction. Thus, based on the transportation information currently available at the time, dog searches have been emphasized in areas where the potential has been greatest for vessels and cargo to depart for vulnerable destinations.

The detector dog program has developed from the original 2 dog/handler teams to the 10 now in use. Since the program was begun in 1993, the number of inspections has been increasing and the rate of snake captures per dog has been decreasing. This is very likely due to the implementation and maintenance of trapping programs and spotlight searches of fence lines in the vicinity of air- and sea-port areas. Trapping has been demonstrated to be effective for removing brown tree snakes from the fragmented jungle habitat adjacent to port areas (Engeman et al., 1998a, 1998b) and spotlight searches also remove significant numbers of snakes from these areas (ADC unpublished data). Because of these efforts, it is likely that fewer snakes are available to invade cargo staging locations from surrounding areas. Snakes, however, can still be transported inside those areas in vehicles or cargo. Locations that have been identified as high risk for contamination of cargo with snakes, such as facilities within the Harmon industrial area where cargo originates and is containerized prior to transport to ports, are being targeted for development of agreements for teams to conduct detector dog inspections and trapping.

In these areas, inspections of cargo and cargo holding areas may result in an increased capture rate of snakes using dogs until enough trapping has been conducted in those areas to deplete snake populations.

Examination of the cases where detector dogs have found snakes clearly demonstrates the immediate potential for human transportation activity to bring about further dispersal of brown tree snakes. A variety of control methods and strategies for control of brown tree snakes are effective and available (e.g., Engeman et al., 1998a, 1998b; Linnell et al., 1997), while others are being identified and developed (Brooks et al., 1998, 1998; Savarie et al., 1998). The spread of the brown tree snake from Guam is best deterred through an integration of control methods, including dog inspections as a last line of defence for outbound cargo. A study to define the efficacy of the detector dogs is currently underway; however, a thorough understanding of cargo flows from Guam is necessary to make effective use of the dogs (and other control methods) as a deterrent to dispersal. Compilation of cargo transport information, concomitant with risk assessment and coordination of control activities with commercial and military air- and sea-port authorities, has evolved significantly (Linnell and Pitzler, 1996). Risk assessment should be further refined by data currently being collected on environmental conditions in vessels and cargo containers as a means of assessing the prospects for snake survival through the most likely transportation avenues. Use of detector dogs to inspect cargo arriving from Guam at major destinations particularly vulnerable to the introduction of the brown tree snake might further reduce the chance of accidental introductions. The prospect of inadvertently dispersing brown tree snakes from Guam will be minimized by maximizing the application of effective control methods to situations presenting a potential for snake export.

#### Acknowledgements

M. Fall, R. Bruggers, J. Shivik, P. Egan, H. Bolton and G. Rodda provided valuable reviews of the paper. This operational assessment was conducted under funding provided to the U.S. Department of Agriculture/Animal and Plant Health Inspection Service/Animal Damage Control by the U.S. Department of Defense under DOD MIPR-064-95, "Operational Control of Brown Tree Snakes in Guam."

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