Effectiveness of the detector dogs used for deterring the dispersal of Brown Tree Snakes

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The accidental introduction of the Brown Tree Snake *Boiga irregularis* to Guam has resulted in the extirpation of most of the island's native terrestrial vertebrates, has created a health hazard to infants and children, and has resulted in economic losses. Cargo inspections using teams of handlers and their detector dogs form a last line of defense for preventing Brown Tree Snake dispersal from Guam. To assess the efficacy of the teams of handlers and their dogs for locating stowed Brown Tree Snakes, we planted Brown Tree Snakes (in escape-proof containers) in cargo without the knowledge of the handlers inspecting the cargo. We found that when an observer attended the inspection to monitor procedures, 80% of the planted snakes were located. Without an attending observer present, 70% of the planted snakes were discovered, but only after such plantings had become a routine procedure. Prior to the routine planting of snakes, efficacy was nearly 50% less (38%). The reasons some planted snakes were missed by the dog teams were split between: an insufficient search pattern by the handler, or the dog giving no discernable indication that a snake was present.

Key words: *Boiga irregularis*, Canine inspections, Cargo inspections, Dispersal, Exotic species, Guam, Snake control.

INTRODUCTION

THE Brown Tree Snake *Boiga irregularis* on Guam is a prime example of the effects that an introduced predator can have on insular populations of native fauna. This snake, accidentally introduced to Guam in the 1940s (Rodda *et al.* 1992), has extirpated nearly all of the native forest avifauna (Savidge 1987). The fruit bat populations on Guam, already severely impacted by hunting, have suffered additionally through Brown Tree Snake predation (Wiles 1987a,b). In addition, several indigenous or endemic species of lizards have become extinct or endangered because of snake predation (Rodda and Fritts 1992). The Brown Tree Snake also has become an agricultural (Fritts and McCoid 1991) and an economic pest (Fritts *et al.* 1987). Furthermore, this rear-fanged colubrid snake is mildly venomous and poses a potential health hazard to infants and young children (Fritts *et al.* 1990).

The Brown Tree Snake may impact other islands in the future, as it is well-adapted for successful transport to, and establishment at, other locations (Rodda *et al.* 1997). Brown Tree Snakes are highly mobile, agile climbers that seek refuge from heat and light during the daylight hours. Shipping containers and many types of cargo, as well as air and sea craft, may offer ready daytime refugia. The high densities of Brown Tree Snakes on Guam, and the position the island has as a focal point for shipments of commercial and military cargo in the Pacific, increase the threat of Brown Tree Snakes finding their way into outbound air and sea traffic. Definitive sightings have been made on a number of Pacific islands (McCoid *et al.* 1994) and an incipient population is speculated to exist on Saipan in the Commonwealth of the Northern Mariana Islands (McCoid *et al.* 1994). This, coupled with the ecosystem fragility of other Pacific island to which much outgoing cargo flows, has made the potential spread of the Brown Tree Snake from Guam a serious concern.

The control of Brown Tree Snakes has been implemented at Guam's air and sea port facilities, and other areas of high risk, to curtail the dispersal of the snakes from Guam. The control effort involves the capture of Brown Tree Snakes from the high risk areas using a variety of trapping strategies (Engeman and Linnell, in press; Engeman *et al.* 1998a,c) and nocturnal searches of fence lines using spotlights (Engeman *et al.*, in press). In addition, detector dogs are used on cargo deemed as high risk for exporting Brown Tree Snakes. A large portion of the cargo flow from Guam has been defined and categorized according to the potential for dispersing Brown Tree Snakes to vulnerable destinations (Linnell and Pitzler 1996; Vice *et al.* 1997).

Much of the cargo exported from Guam originates from areas of the island beyond where snake removal efforts are applied. Thus, cargo destined to susceptible locations and the associated cargo holding facilities are subjected to inspections for snakes using detector dogs. An examination of the case histories for each snake located by detector dogs revealed that more than 80% of those snakes were either in, or nearby, cargo with potential Pacific island destinations (Engeman *et al.* 1998b). In this paper, we examine the efficacy of the teams of

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handlers and their dogs for locating snakes during operational cargo inspections. We also identify reasons why snakes might go undetected during an inspection.

METHODS

Standard inspection procedures — Cargo, cargo staging areas, and transport vessels identified as posing a risk for accidental introduction of a Brown Tree Snake to a vulnerable location are subjected to inspections by detector-dog teams. Each team comprises a handler and the unique detector-dog (Jack Russell Terriers) assigned to that handler. A variety of commercial and military locations are inspected (Engeman *et al.* 1998b) and three shifts of handlers and their dogs are available 24 hours for conducting inspections. Each handler is responsible for scheduling the route between his assigned inspection sites. Close co-ordination with facilities managers is required to insure that outbound cargo, and transport vessels when necessary, are inspected. Some large cargo facilities may require two or three dog teams to inspect.

Placement of test snakes — We planted live Brown Tree Snakes in cargo in advance of an inspection and without the knowledge of the handler(s) responsible for conducting the inspection. Prior to placement in cargo, we put the snakes in escape-proof containers (capped PVC pipes), which were ventilated to allow scent to escape and the snakes to breathe. Because the snakes entering cargo "naturally" were discovered in a wide variety of circumstances (Engeman *et al.* 1998b), we hid the snakes randomly at any depth within the cargo, or in the immediate vicinity of the cargo, always so that the snake containers would not be visible to handlers or dogs and at least 1 hour before an inspection. By putting snakes in containers, we likely produced a more severe test of a dog's ability to detect snakes in cargo, because there would be no scent trail to the hidden snake. All snakes that were not located by the dogs and their handlers were retrieved. As an added precaution, facility employees at the inspection sites were shown the locations of planted snakes and informed to remove them if the cargo had to be moved. They were advised, and co-operated well, to not intentionally or unintentionally alert the handlers that a snake had been planted. To insure that dogs would not key on the odours that may accumulate on containers from previous snakes and mouthing by dogs, we thoroughly washed containers with soap and water prior to reusing them and we also conducted numerous trials to verify that the dogs could not detect cleaned containers without a snake inside. We considered four conditions for addressing our objectives.

1. Observer attending inspections — During this first condition from which we collected data from August, 1996 to February, 1997, an observer (usually a dog trainer) would occasionally attend operational inspections to insure that inspection procedures were being followed correctly. We used some of these occasions as opportunities to assess the efficacy of the handlers and their dogs for locating planted snakes. Undisclosed planting of snakes prior to these observed inspections provided an opportunity to collect detailed observations on the reasons that snakes could go undetected. Planting times and locations had to coincide with availability of outbound cargo that would prompt an inspection. Planting locations were selected randomly from among those where an inspection would take place. Snakes only occasionally were planted prior to inspections, so that handlers (and dogs) would not assume snakes had been planted each time an observer was present. Nevertheless, we presumed the presence of an observer could influence the handlers to conduct more thorough inspections and thus bias efficacy estimates upwards. Data recorded during these inspections included the location and type of cargo or craft being inspected, the number of snakes planted and located, the dog team that inspected the specific location where each snake was hidden, and descriptive observations as to why snakes, if any, were missed.

2. Transition period, no observer attending — The second condition in which we collected efficacy data was from mid-February to mid-June, 1997 and was designed to avoid the bias in inspection procedures that might have resulted from having an observer present. Snakes were planted in advance of inspections as above, but no one attended the inspections to observe inspection procedures. Dog handlers were always under instructions to report any snakes located in cargo, wild or planted. These data were more likely to provide an unbiased assessment of efficacy for locating snakes, but could not provide any information about why snakes might go undetected, We anticipated that initiation of these trials might cause handlers to inspect with increasing intensity, possibly resulting in increasing efficacy as they realized that a snake could be planted at any inspection site. Therefore, we defined this second condition as unobserved inspections during a four month transition period. Data were collected on the number of snakes planted at each facility, the number found, and the team(s) responsible for each inspection.

3. Post-transition, no observer attending — The third data collection condition was for the unobserved inspections conducted after mid-June, 1997. After four months of occasional planting of snakes for unattended inspections, we assumed that handlers would be alert to the possibility of planted snakes for any given inspection, and efficacy at locating snakes then would be at a stable level. The same type of observations were made during this phase as during the transition period.

4. Post-transition, concealed observer — The fourth, and last, data collection condition was a subset of the third. We still wanted information on why a portion of snakes in cargo might escape detection during an inspection. Snakes were planted as for the second and third conditions. However, in an attempt to obtain information on causes for not locating any snakes that might have gone undetected, we placed an observer out of sight of the handlers at some inspection sites. Many of these observations were conducted discreetly from inside a parked car and/or at a distance using binoculars. The same data as for conditions two and three were collected, as well as observations on the search procedures. By logistical necessity, these data were limited in quantity because they were difficult to obtain. Prior to the arrival of the handlers with their dogs at an inspection site, the observer had to plant snakes and position himself such that he could make observations without being seen. This was accomplished without precise knowledge of the inspection schedule, other than that an inspection of the facility would take place during that shift.

RESULTS

1. Observer attending inspections — During the inspections where snakes had been planted in cargo and an observer was visibly present to monitor the inspection procedures, 49 of the 61 (80%) planted snakes were located by the dog teams. We defined two general categories for the reasons that the other 12 snakes were not located during the inspections. The first reason was lack of a thorough or complete search pattern. Examples of this include overlooking a portion of the material or area to be inspected, or not elevating the dog to inspect the upper portions of stacked cargo. Of the 12 missed snakes, five (42%) fell into the lack of a thorough search pattern category. The other seven (58%) misses fell into a category we labeled as non-responses, which could be due to the dog not detecting the snake, the dog not presenting sufficient response to a snake for the handler to detect and respond to the dog's prompts, or the handler not sufficiently coaxing/commanding the dog to elicit a response.

2. Transition period, no attending observer — Thirty-nine snakes were planted for inspections in the transition period and 15 (38%) of these were located by the dog teams. Because no observer was present, we cannot assign reasons for the significantly higher rate of misses than when an observer was present ($X^2 = 18.1$, df = 1, $p < 0.001$).

3. Post-transition, no attending observer — A substantially higher detection rate (nearly double) occurred for the post-transition period, as 35 of the 50 (70%) snakes planted in advance of the inspections were found by the dog teams. This detection rate was significantly greater than for the transition period ($X^2 = 8.9$, df = 1, $p = 0.003$), but was not distinguishable from the detection rate when an observer was present ($X^2 = 1.6$, df = 1, $p = 0.207$).

4. Post-transition, concealed observer — Of the above 50 post-transition snakes planted, we were able to discreetly observe the inspections for 19 of them. Of these, 12 were found by the dog teams (63% discovery) and seven were missed. As would be expected if the inspections with concealed observers were representative of all inspections involving planted snakes, no differences were found in the detection rates with and without a concealed observer present ($X^2 = 1.04$, df = 1, $p = 0.308$). Using the same previous two categories for classifying reasons the snakes were missed by the dog teams revealed that four (57%) of the misses were due to an incomplete search and three (43%) were due to non-response.

DISCUSSION

The efficacy of the handlers teamed with their dogs is a difficult subject to study, as it involves a complex interaction between an animal and its human handler. The human must correctly train and apply the dog, and then accurately interpret the dog's behaviour, which, like human behaviour, can vary from day to day. Observing when a handler does not thoroughly search an area is straightforward, but quantifying the human–dog interaction in an attempt to understand reasons for non-response to a snake is difficult, perhaps impossible. On top of this, there has been some debate as to the seasonality aspects of Brown Tree Snake behaviour (G. Rodda, pers. comm.), and similarly, there may be seasonal influences on the diffusion of snake odours and canine behaviour, all of which evidence the need of multiple years of dog efficacy data to sort out these possible influences.

We felt that the current (post-transition period) estimated detection rate efficacy of 70% was a significant achievement. Hypothetically, efficacy could be raised by an amount similar to the rate of insufficient search patterns (21%, 4 of 19, during post-transition with concealed observers), less those additional snakes that would be missed due to non-response. Perhaps additional training procedures also could be devised to reduce the rate of non-response by the dogs (16%, 3 of 19, during post-transition using concealed observers) to further elevate efficacy. On the other hand, we also assume discontinuing the random trials of the dog teams with planted snakes would lead to decreased attentiveness to inspection procedures and a subsequent decrease in efficacy. We observed that finding planted snakes instills confidence in the dogs from their handlers and raises morale. At the same time, facility workers and managers where inspections occur have shown greater confidence and interest in the abilities of the handlers and dogs. This has led to more proactive snake control efforts by employees at regularly inspected facilities.

Although handlers and dogs are available 24 hours each day, they serve in a co-operative, rather than regulatory, capacity. As such, they are not stationed at ports of entry/exit and use of the dog teams in cargo is the result of co-operative arrangements and co-ordination with agencies, organizations, and companies transporting cargo from Guam. Thus, a thorough understanding of cargo transport from Guam is necessary to effectively use 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; Vice *et al.* 1997). Risk assessment should be further refined by data currently being collected on environmental conditions in vessels and cargo containers. This information will help assess the prospects for snake survival through differing transportation avenues. The use of detector dogs to inspect inbound cargo from Guam at destinations particularly vulnerable to the introduction of the Brown Tree Snake may further reduce the chance of accidental introductions.

As data from more trials using random, undisclosed planting of snakes are collected over time (especially using concealed observers), a number of more detailed questions and concepts could be examined. The effects on efficacy of time-of-day, indoor versus outdoor inspections, weather conditions, and the materials/vessels being inspected could be addressed. The variability in efficacy between teams of handlers and their dogs, and within each team, could be evaluated and used to assess when a new dog or handler has achieved a level of efficacy suitable for independent operational inspections. Possibly, process quality control methods could be applied to alert managers if efficacy slips below an acceptable level. Certainly, future detector dog efficacy could be compared to the baseline established here.

Even without a much larger database suitable for addressing more detailed questions, the results presented here lead us to recommendations concerning the detector dog programme for Brown Tree Snakes. Because the expectation that a snake could be planted in cargo resulted in higher efficacy for discovering planted snakes (post-transition period), the random placement of snakes in search locations should be considered as a regular component of the inspection programme. Continued discreet observations of inspections would potentially provide managers with information on where training should be emphasized, both on an individual and progammatic basis; handler inspection techniques, dog identification of scents and cues to handlers, etc.

A programme integrating multiple snake control tools is in place at port and other major cargo staging facilities on Guam. Since implementation of intensive and extensive removal of snakes (e.g., Engeman *et al.* 1998a) in the vicinities of ports and other cargo staging areas through trapping and fence line searches, the discovery of snakes in cargo has become less common. When a snake has been found during an inspection, it usually has been in a position to be transported to a vulnerable location (Engeman *et al.* 1998b). Thus, a high degree of attentiveness on the part of the handlers and their dogs is required. The use of planted snakes serves as an effective training tool to enhance attentiveness, as well as serving to evaluate efficacy of detector dog inspections.

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