21 Barriers to Movements of the Brown Treesnake *(Boiga irregularis)*

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While it is presently not practical to eliminate established populations of the Brown Treesnake, ***Boiga irregularis,*** it may be possible to control this species on a smaller scale. Snake densities in an area can be lowered if resident snakes are removed and dispersal into the site is eliminated (Rodda et al., this volume, Chap. 39). One way to reduce movement into an area is to build a physical barrier. In the case of the more sedentary Habu (Trimeresurus flavoviridis), barriers have been effective at maintaining snake-reduced or snake-free zones (Shiroma and Akamine, this volume, Chap. 24). Barriers can also be used to prevent snakes from entering cargo or vehicles that might spread them to new islands. Given the high dispersal rate of the Brown Treesnake (Rodda et al., this volume, Chap. 17), an effective barrier to dispersal might be particularly useful.

Electrical fencing is commonly used to control the movements of domestic and wild animals (McKillop and Sibly, 1988); however, the use of such barriers to control snake dispersal has been limited to efforts of Japanese herpetologists to control the movements of Habu (Hayashi et al., 1983, 1984). Electrical barriers are presently being used to stop Habu from entering villages on Tokunoshima and Amamioshima (Tanaka et al., 1985, 1987). They are also being used to prevent Habu from entering electrical substations in Okinawa Prefecture (Y. Miyagi, pers. comm., 1992). Stimulated by the Japanese successes, the staff of Guam's Division of Aquatic and Wildlife Resources is placing electrical barriers on trunks of trees used by nesting pairs of endangered Mariana Crows (Corvus kubaryi; Aguon et al., this volume, Chap. 38) to reduce Brown Treesnake predation on eggs and chicks.

Nonelectrified barriers are also used to control snake movements. Nylon mesh, metal mesh, and concrete block fences have been designed to reduce Habu dispersal, with varying degrees of success (Shiroma, 1981; Nishimura, 1983, 1984b, 1984c). The most cost-effective design is a 70-cm-high, 9-mm-square mesh nylon fence placed at a 60 deg angle to the ground and secured to the substrate to prevent Habu from crawling underneath it (Nishimura, this volume, Chap. 22). Traps have been designed to be placed against the net fence near required openings (e.g., roads) to reduce the chance that snakes moving along the fence will enter protected areas (Nishimura, 1984a, this volume, Chap. 22). The net fence is presently being used in association with Habu traps in an experiment to reduce Habu den-

CAMPBELL 111, E. W. 1999. Barriers to movements of the brown treesnake *(Boiga irregularis).* Pages 306-312 *in* Rodda, Gordon H., Sawai, Yoshio, Chiszar, David, and Tanaka, Hiroshi, editors. Problem snake management : the habu and the brown treesnake . Cornell University Press, Ithaca, NY. 534p.

sities in Kitanakagusuku Village, Okinawajima (Shiroma and Akamine, this volume, Chap. 24). This chapter describes tests of electrical barriers that may ultimately be used to exclude the Brown Treesnake from endangered species' habitats, power stations, ports, and other areas.

METHODS AND MATERIALS

I tested the efficacies of various snake barrier designs in two experiments (Table 21.1). The results of the first experiment were used to refine the design of the fences tested in the second experiment. For both, I put individually marked snakes in 3.5 x 3.5m enclosures for several days to quantify escape and mortality rates (Table 21.1). I determined the fates of all snakes in every enclosure each morning. I predict that both escape and mortality rates of snakes on fences in the wild will be much lower than they were in the test enclosures, because a snake repelled from a fence in the field is not as likely to encounter another fence.

In the first experiment, two fencing materials were tested with four different wiring configurations (Table 21.1). In the second experiment, one fencing material was replaced and one wiring configuration was abandoned. During the second experiment I recorded whether snakes died on the fence or nearby. I also conducted tests with a larger snake sample size for a shorter period (Table 21.1). In addition to experiments 1 and 2, I watched 10 snakes individually at night in each of the enclosures to see the behaviors involved in moving over, under, or through the fences.

I used a Speedrite HB12 electrical fence energizer (3700V @ 500 ohms, 1.2J maximum output) to charge 16 gauge aluminum Wire. Enclosures were constructed out of three different fencing materials (1) Tensar Polygrid WB (Tensar Corp., Morrow, Ga), a UV-treated high-density polyethylene fencing material with 24.5 x 5.5 mm oval holes; (2) W-treated high-density polyethylene netting (Memphis Net and Twine Co., Memphis, Tenn.) with 6.5 mm x 6.0 mm parallelogram holes; and (3) hexagonal knotless nylon netting with 7.5 mm holes (Memphis Net and Twine Co., Memphis, Tenn.).

The fences were approximately 110 cm tall with a variety of charged wiring configurations (Table 21.2). During all trials the negative wires were grounded. The bottom wire was positively charged and higher wires were alternately posi-

Table 21.1 Snake barrier designs, sample sizes, and durations of enclosure experiments.

	Exp. 1	Exp. 2
Number of designs tested	8	5
Fencing materials tested	Tensar, polyethylene	nylon net, polyethylene
Wiring configurations (no.)	4	3
Snakes tested per design	10	>50
Duration in enclosure (days)	7	3

tive and negative. I attached wires to the inner surface of the polyethylene fencing materials using cable ties. Before initiating this study I observed large snakes forcing their heads underneath fencing material and escaping. I subsequently buried fencing materials 10 cm into the ground.

RESULTS AND DISCUSSION

During the first enclosure experiment, snake escape rates ranged from 0 to 40% and mortality ranged from 30 to 90% (Fig. 21.1). Although overall escape rates were low for the Tensar fencing materials, behavioral observations suggested that

Table 21.2 wiring configurations of four electrical barrier prototypes.

No. wires	Height of wires above the ground (mm)				
5	10 (+)	30 (−)	50 (+)	70 (−)	90 (+)
4		30 (+)	50 (−)	70 (+)	90 (−)
3			50 (+)	70 (−)	90 (+)
4a	10 (+)		50 (−)	70 (+)	90 (−)

Note In all cases negative conductors (−) were grounded; positive conductors (+) were charged.

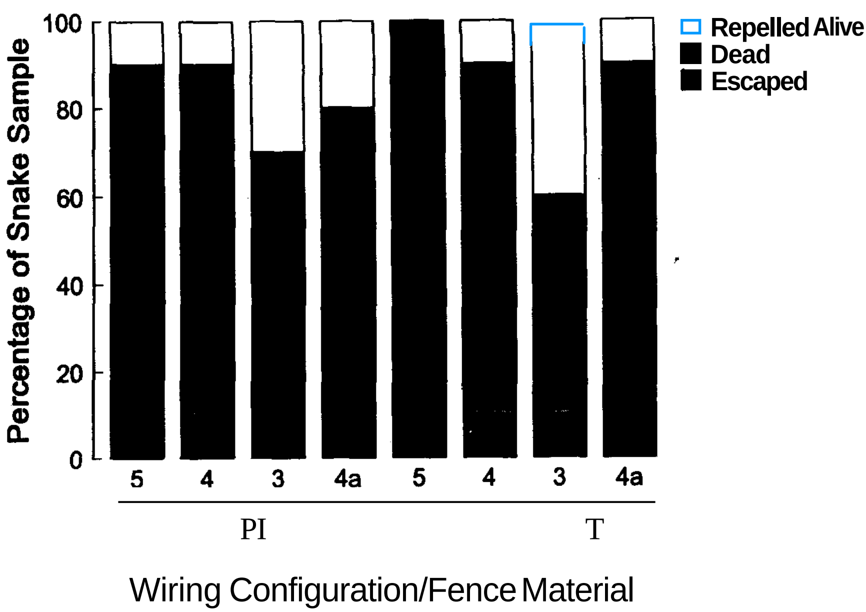

Figure 21.1 Fate of snakes in experiment 1. two fence materials were tested: polyethylene netting with 6.5 mm x 6.0-mm parallelogram holes (PI) and Tensar Polygrid WB with 24.5 X 5.5 mm oval holes (T). Four different wiring configurations were tested (see Table 21.2).

small snakes could not be prevented from going through the large mesh; therefore, I stopped testing this material. Dead snakes hanging across charged wires could short-circuit the electrification, rendering it useless. Starting with the second experiment, I collected data on the site of snake mortality.

In the second experiment, testing continued on the five- and four-wire polyethylene netting fences. A new fencing material, nylon netting, was also tested, in three different configurations. Escape rates in the second experiment ranged from 0 to 37% for the various fencing designs (Fig. 21.2). There were no escapes from the five-wire nylon and polyethylene netting enclosures, and the four-wire nylon netting enclosure had only a 2% escape rate. Mortality of snakes ranged from 20 to 78% (Fig. 21.2). Results bearing on barrier design can be grouped into three general topics: conductor–fencing material compatibility, effective wiring configurations, and difficulties associated with excluding a broad range of snake sizes.

The stiffness of the polyethylene fencing material made it very difficult to attach conductors so they would remain close to the plastic mesh. Over the passage of time, even minor irregularities in the supporting terrain caused deep furrows in the fencing material between attachment points. Many snakes died dur-

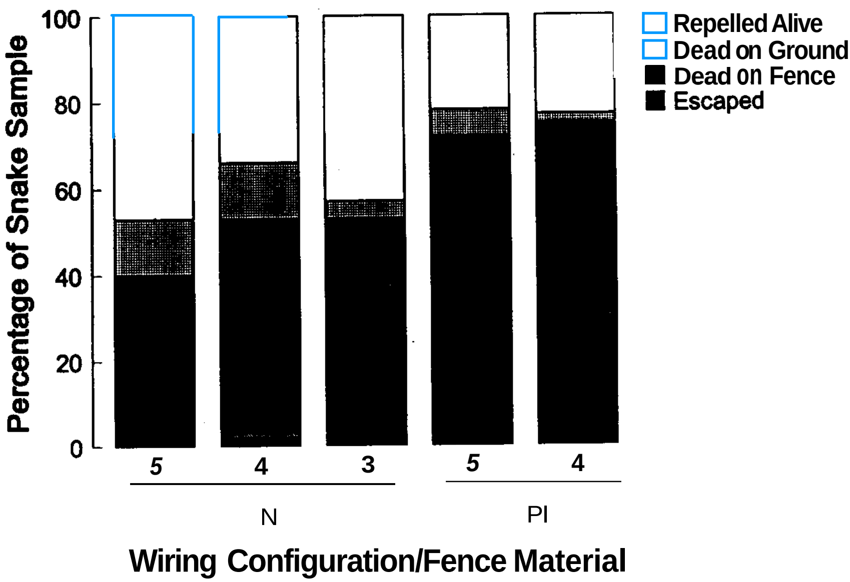

Figure 21.2 Fate of snakes in experiment 2. Two **fence materials were tested hexagonal** knotless **nylon netting with 7.5-mm-wide holes (N) and polyethylene netting with 6.5 mm x 6.0 mm parallelogram holes (Pl). Three different wiring configurations were tested (see Table 21.2).**

ing the first experiment hanging near or holding onto the cable ties used to attach charged wires to the polyethylene fencing materials.

The nylon netting tested in the second experiment did not need cable ties, reducing furrows and the number of dead snakes hanging on the fence. I compared the site of snake death, either on the ground or on the fence, to determine if fences constructed out of nylon netting had a lower chance of being rendered inoperable by dead snakes hanging on wires (Fig. 21.2). Fewer dead snakes were found on wiring of the tieless nylon netting designs ($G_1 = 6.388$, $P < 0.05$). Of the two fencing designs that permitted no escapes during the second experiment, the five-wire nylon configuration had the lowest percentage of snakes that died on the conductors. The nylon four-wire fence also had a significantly lower escape rate than the polyethylene four-wire fence ($G_1 = 34.087$, $P < 0.001$). With the exception of the Tensar fences, all fence designs had an inverse relationship between snake escape rate and mortality ($r_6 = -0.841$, $P < 0.002$).

Differences in wiring configuration effectiveness were also observed. Snakes had a greater chance of escaping as the number of wires on polyethylene or nylon netting enclosures decreased (Figs. 21.1 and 21.2; $r_7 = 0.887$, $P < 0.005$). This is because of the increased chance that a snake will encounter an electrified wire and be repelled.

Finding an effective barrier to exclude all size classes of snakes proved to be problematic. The Tensar fencing material tested in experiment 1 had low escape rates for all wiring configurations; however, I observed a Brown Treesnake with a snout-vent length of 420 mm passing unimpeded through the material. I ceased testing this material because it was not available in a smaller mesh size.

I made behavioral observations on a large Brown Treesnake (snout-vent length >1350 mm) for each enclosure in the second experiment. This individual was placed in each enclosure and could escape all fencing designs. Fortunately, snakes this large are presently very rare at most sites on Guam, and most individuals of this size are male (Rodda et al., this volume, Chap. 17). This suggests a low risk of a potential colony foundress entering a site surrounded by an electrical barrier.

In conclusion, the five-wire nylon netting fence was the most successful barrier design for stopping Brown Treesnake dispersal. No snakes escaped through this fence, except for the large snake mentioned above. This design merits testing on a larger scale (Shiroma and Akamine, this volume, Chap. 24; Rodda et al., this volume, Chap. 39). Eventually, barriers such as this one may be used to keep Brown Treesnakes out of electrical facilities, ports, airports, and wildlife habitat.

ACKNOWLEDGMENTS

The U.S. Department of the Interior provided funding for this work. Logistical assistance on Guam was provided by Mike McCoid and the staff of the Division of Aquatic and Wildlife Resources and Heidi Hirsh at Andersen Air Force Base. Logistical assistance in Ohio was provided by Jon Bart and Diane Rano at the Ohio Cooperative Fish and Wildlife Research Unit. I thank Craig Clark, Rick Blakely, Tom Fritts, and Gordon Rodda for assistance in the field. Gregers Campbell, Mike McCoid, Tom Fritts, and Craig Clark suggested improvements to the manuscript.

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