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A rat-resistant artificial nest box for cavity-nesting birds

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Abstract: The puaiohi or small Kauai thrush (*Myadestes palmeri*) is an endangered bird endemic to the island of Kauai, Hawaii. The sole population of about 500 birds is currently restricted to remote, higher elevation areas of the Alakai Plateau. Puaiohi nest primarily on steep streamside cliffs, and their distribution and abundance are limited by availability of suitable nesting sites. Black rats (*Rattus rattus*) cause nest failure and mortality of nesting female puaiohis, and ground-based rodent control has not been effective at reducing nest predation. In 2007, we investigated whether artificial nest structures might be a viable alternative to rodent control by testing nest-box designs to find one that was resistant to rats. In laboratory trials, we evaluated 3 designs that were currently being deployed as artificial nest boxes for puaiohi and found that they were not rat resistant. From these results, we developed and tested an improved design. Captive rats were unable to enter a nest box made from a 36-cm length of 15-cm-diameter plastic pipe with an overhanging entrance cut at an angle of 49°.

Key words: artificial nest, Hawaii, human–wildlife conflicts, introduced predators, *Myadestes palmeri*, nest predation, puaiohi

Birds that evolved on oceanic islands without mammalian or reptilian predators are particularly susceptible to nest predation, and introduced predators are one of the most serious threats to many island birds (Savidge 1987, Thibault et al. 2002, VanderWerf 2009). Efforts to control or eradicate introduced predators can be effective (Côté and Sutherland 1997, Parkes and Murphy 2003), but often they are expensive and labor intensive, and unless predators are eradicated from an entire island, control must be conducted indefinitely.

For some bird species, predator-resistant artificial nest structures can provide an alternative means of reducing predation. Nest barriers, such as metal tree collars, are another method that has been used to reduce predation on bird nests (Hicks and Greenwood 1989, Robertson et al. 1994, Garnett et al. 1999), but this technique is less practicable for birds that nest on cliffs or in forests with a dense canopy of interlocking branches. Artificial nests have been effective at increasing reproduction in some cases (Bock and Fleck 1995, Major and Kendall 1996), but the ability of these structures to exclude the predators they are designed against often has not been tested, and there is little information available about which aspects of their construction render them predator resistant (Greene and Jones 2003).

The puaiohi (*Myadestes palmeri*), also known as Kauai thrush, is an endangered solitaire endemic to the Hawaiian Island of Kauai (Figure 1). The population of puaiohi is approximately 500 birds, which are restricted to remote, high-elevation areas (<4000 ha) of the Alakai Plateau (Snetsinger et al. 1999, U.S. Fish and Wildlife Service [USFWS] 2006, Hawaii Division of Forestry and Wildlife [DOFAW], unpubllished

Figure 1. The puaiohi, endemic to Hawaii, is an endangered species. (*Photo E. VanderWerf*)

data). Puaiohi nest primarily on rock ledges and in shallow cavities of steep streamside cliffs, with a small proportion of nests located in trees, often on large horizontal branches (Snetsinger et al. 2005). Nest predation by black rats (*Rattus rattus*) can be a serious cause of nest failure and mortality of female puaiohi in some years (Snetsinger et al. 2005, Tweed et al. 2006). Due to the extremely low Puaipohi population sizes, the use of rodenticide bait stations is rarely stopped. Black rats predated on more than 36% of nests in 1997 when nests were not protected by rodenticide bait stations (Snetsinger et al. 2005). Recent surveys indicate puaiohi may occupy all habitat with suitable cliff-nest sites in the Alakai region (Hawaii DOFAW, unpublished data), so their distribution and abundance appear to be at least partly limited by availability of cliff-nest sites.

Given the puaiohi's current very small population size and limited distribution, management is urgently needed to prevent any further decrease. Ground-based rodent control using toxicant bait stations and snap traps placed near nests were not effective at eliminating nest predation (Tweed et al. 2006). Larger-scale rodent-control grids will be logistically difficult to maintain in remote areas of the Alakai and could damage sensitive native forest habitat. Rat-resistant artificial nest boxes may be a more practical means of decreasing predation on puaiohi nests and increasing availability of nest sites. Captive puaiohi readily nest in artificial nest boxes (Kuehler et al. 2000), so nest boxes also could be used by birds in the wild.

Thirty-three artificial nest boxes were erected by the Hawaii Division of Forestry and Wildlife in upper Kawaikoi and Halepaakai streams between 2000 and 2003. One box along Kawaikoi Stream was used successfully by a pair of puaiohi to fledge 2 chicks in 2002 (T. Savre, Kauai Forest Bird Recovery Project, personal communication). If puaiohi will consistently use rodent-resistant nest boxes in the wild, this technique has the potential to improve nest success and survival of breeding females, and to increase the species' population density and range, at a modest cost. The primary objective of this study was to test artificial nest box designs for predator resistance in a laboratory setting, and if necessary, refine the nest-box design to improve resistance to black rats.

Methods

Artificial nesting structures must have 2 characteristics to be effective at reducing nest predation: (1) attractiveness to the bird species of interest, and (2) resistance to potential nest predators. We tested designs that were already known to be attractive nest sites to captive puaiohi.

In captivity, puaiohi have readily used nest boxes made from horizontal lengths of rigid plastic pipe (Figure 2A, B, C). The nest box used successfully by a pair of wild puaiohi in 2002 was made from a plastic flower pot (Figure 3). Neither of those designs was rat resistant, but it seemed more likely that modification of the plastic tube design would render it rat resistant, so we tested various modifications of that design.

Initially, we evaluated 3 prototype designs that were deployed in the field for puaiohi and used in the captive breeding program. The first prototype nest box used by captive puaiohi was a 20-cm-long piece of 15-cm diameter Acrylonitrile-Butadiene-Styrene (ABS) plastic pipe mounted horizontally on a wooden base using toed-in 3.1 cm wood screws (Figure 2A). A semicircular piece of wood was screwed into the entrance to prevent the nest from slipping out and to provide a perch for birds entering and leaving the nest. A row of holes was drilled along the bottom of the pipe to allow drainage and increase air flow. This basic design was modified in hopes of making it more rat resistant (Figure 2B). Design B used a longer, 35-cm length of pipe, and an overhanging entrance was created by cutting the pipe at a 30° angle. In tests of artificial nests designed for the kaka (*Nestor meridionalis*), a large parrot endemic to New Zealand, Greene and Jones (2003) found that addition of an overhanging hood to vertically mounted plastic nest tubes was required to successfully exclude stoats (*Mustela erminea*). The final prototype was made using 10-cm diameter ABS pipe (Figure 2C), because the narrower pipe was cheaper and easier to transport. Twenty-five nest boxes (designs A, B, and C) were deployed in the field from 2007 to 2008 for puaiohi use in areas where wild population and capture-raised birds were released. Based on results of trials on these first 3 designs (see Results), we created a fourth design, in which the angle of the overhang at

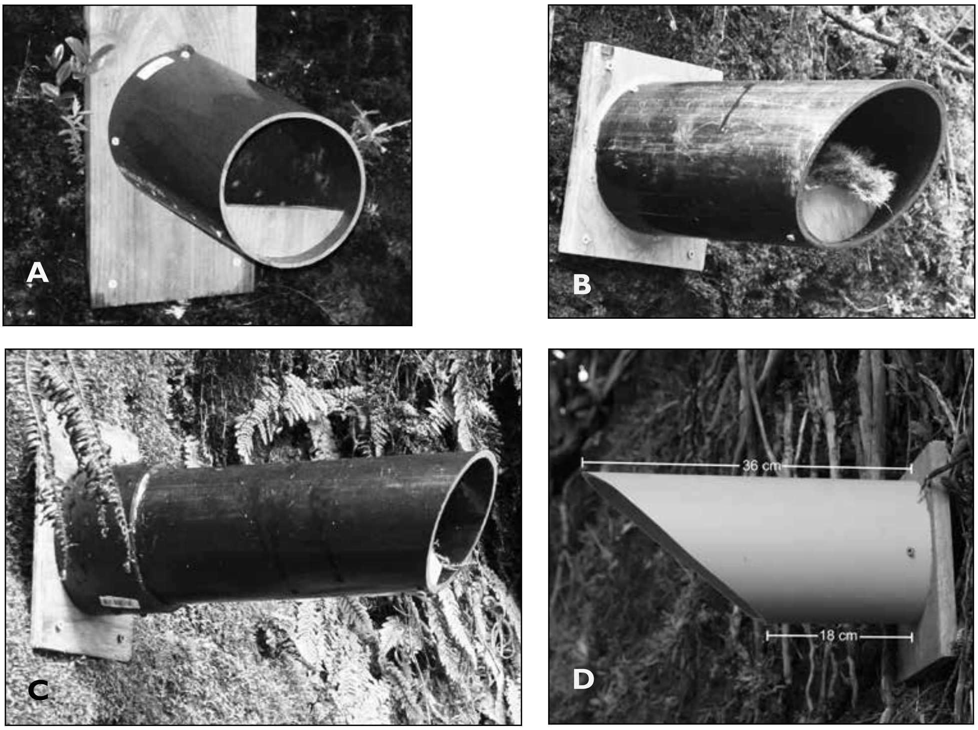

Figure 2. Plastic pipe nest-box designs tested for rat resistance and puaiohi preference: (**A**) 20-cm long, 15-cm diameter pipe with a vertical entrance, which is the type used by puaiohi in captivity; (**B**) 35-cm long, 15-cm diameter pipe with an overhung entrance created by a 30 ° bevel; (**C**) 35-cm long, 10-cm diameter pipe with an overhung entrance of 30 °; (**D**) improved design made by NWRC in which the angle of the bevel was increased to 49 ° to create a larger overhang on a 15-cm pipe.

the opening of the pipe was increased to 49° (Figure 2D).

Wild black rats were live trapped in and around Hilo, Hawaii, and transported to the National Wildlife Research Center Field Station where they were quarantined 24 hours prior to testing and housed during the study. A 1.5-m 1.5-m × 1.4-m test chamber made of stainless steel panels was used to contain rats around the nest box being tested. We tested 3 artificial nest box designs (Figure 2A, B, C). We deleted nest-box design A because we assumed that if rats could enter design B, then they could also enter design A, which lacked an overhanging entrance. We tested 1 nest-box design at a time with 1 rat. We secured each nest box to a wooden stand placed in the center of the test chamber (Figure 4). We elevated the nest box so that rats were discouraged from attempting to access it by jumping, but rats could easily access the nest box by climbing the wooden stand. We baited nest boxes with coconut. We evaluated each design with 3 rats of each sex, unless a rat successfully entered the nest box, in which case trials with that design ceased. We selected black rats of varying size classes (weight ranges of 102g to 205g) for testing. We exposed each animal to a nest box for 24 hours and checked the box for missing, disturbed, partly eaten bait, or any other signs of activity in the nest box (e.g., feces, urine, hair, or gnawing). In addition, we used remote infrared cameras to continuously record rodent activity within the test chamber. The regular maintenance diet was removed during the 24-hour nest-box exposure period. Water was available *ad libitum*. We tested animals that did not gain access to the nest box during the first trial for another 24-hour period.

Results

After being released into the test chamber, rats generally explored the limits of the enclosure and climbed on all objects. While investigating the next box stand, rats climbed to the top of the stand, walked to the front lip of the nest box, and looked down into the nest box. In cases where rats entered the nest box, they did so by

Figure 3. Plastic flower-pot nest boxe built by the Hawaii Division of Forestry and Wildlife from 2000 to 2003. This box was used successfully by a pair of puaiohi in 2002, but rat droppings have been found inside similar boxes.

climbing down the upper side of the pipe and quickly turning into the entrance (Figure 5). During some attempts, rats used screw heads and uneven surfaces to climb down the nest box. Rats that entered the nest box typically consumed all the coconut bait and remained inside for several minutes or longer. Rodents exited the nest box by climbing out the same way they came in or by jumping to the ground.

Nest boxes B and C failed to exclude rats; each design was entered by rats with ease. Nest box B was tested with a 112-g female for 2 consecutive nights. On the first night, it made no attempt to enter the nest box. During the second night, it entered the nest box by accessing it from the top and climbing down the side of the pipe. We tested nest-box C with a 110-g male, which entered the nest box within the first few hours of exposure, again by accessing it from the top and entering from the side.

We tested nest-box D, with the 49 ° overhang, was tested with 6 black rats, 3 males and 3 females, ranging in weight from 103 to 205 g. Each rat was left in the test chamber for 2 nights, during which time the only food was in the nest box. No rats entered the nest box. Video revealed that rats again walked along the top of the pipe and looked over the lip, but they were unable to climb down the side of the pipe into the entrance as they had done with the pipe having a 30 ° overhang. Rats were prevented from entering the nest box because the distance between the top and bottom lips of the pipe was too large for rats to reach while standing on top of the pipe. The overhang and the size of pipe, thus, prevented rats from climbing into the entrance.

Discussion

This study was successful at identifying an artificial nest box design that was resistant to black rats. The key to making the nest box rat resistant was increasing the angle of the overhang to 49°. We believe this modification was effective because the size of the pipe and overhang physically prevented rats from accessing the entrance to the pipe.

Several aspects of construction are important to ensure the nest box tested in this study is rat-resistant. The cut edges of the plastic pipe should be sanded smooth to remove any burrs or nicks, and the sides of the tube should have no cuts or screws that could provide something for rats to grasp. Another important consideration in placing nest boxes in the field is that there must be no vegetation, rock outcrops, or other objects below or to the sides of the nest box that would allow rats to reach the bottom of the tube or jump from adjacent structures. This artificial nest was designed specifically to exclude rats because rats are thought to be

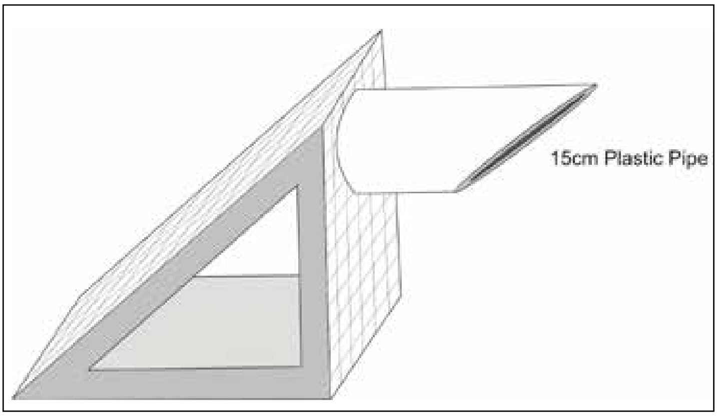

Figure 4. During lab trials, each nest box was mounted on a wooden stand. Wire mesh was added to back (slanted) and front (where box is mounted) of the stand to ensure that rats could access the box.

Figure 5. Video frame showing how black rats entered 2 of 3 nest-box designs. Rats climbed down the curved side of the pipe, then quickly turned into the entrance. Increasing the angle of the overhang to 49° prevented rats from entering the nest box.

the most important predator on puaiohi nests, but it might not be resistant to larger predators or those with better ability to span large gaps, such as snakes. Smaller nest boxes, such as the 10-cm diameter design used in this study, might be resistant to smaller predators, but probably not against larger predators.

Design D tested in the lab did not include the semicircular wooden block in the entrance, but because this block was not used by rats to access the tube in any trials, it probably could be added to design D to make it more attractive to birds without compromising its rat resistance. However, any screws used to secure the block inside the entrance should be located on the bottom of the pipe and not on the sides, and the block should be set back a little from the lower lip of the pipe to reduce the chance that rats might gain access by using the block.

The nest box design identified in this study as rat resistant must also be tested in the field for preference by wild puaiohi. This work has begun, and a number of nest boxes have been placed in puaiohi habitat, but it is too soon to determine whether the boxes will be successfully used by wild birds. Previous studies on artificial nests have shown that if there are many natural cavities in an area, it may be necessary to provide a larger number of nest boxes in order for them to be used (Hicks and Greenwood 1989, Jones and Duffy 1992). Natural rock ledges and cavities are relatively common in some puaiohi territories, so increasing the abundance of artificial nests relative to natural nests might increase the chances they are used. Although one of the older flower pot-type was used successfully by wild puaiohi, rat droppings have been found in such boxes, indicating they are not safe from predators and probably should not be used in the future. We remain hopeful that artificial nest boxes will be a valuable tool for decreasing predation on puaiohi nests and increasing their abundance and distribution.

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