From the Field: Artificial nest cavities for *Amazona* parrots

Thomas H. White, Jr., Wilfredo Abreu-González, Miguel Toledo-González, and Pablo Torres-Báez

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The Neotropical parrot genus *Amazona,* found throughout Mexico, all countries of Central and South America, and most of the major Caribbean islands, is comprised of 31 known species, of which 11 are considered either threatened or endangered (Forshaw 1989, Snyder et al. 2000, Wiley et al. 2004). Habitat degradation and loss currently are among the major threats to the continued survival of virtually all *Amazona* parrots (Collar and Juniper 1992, Wiley et al. 2004). This is because as secondary cavity-nesters, most *Amazona* parrots depend upon mature forests with large, cavity-forming trees for nesting. A notable exception is the Abaco Island population of the Bahama parrot (*A. leucocephala bahamensis*), which nests in limestone solution cavities in the ground (Gnam 1991).

Past and current logging and land-clearing practices throughout the range of *Amazona* have greatly reduced suitable nesting habitat and pushed some species toward extinction (Snyder et al. 1987, Collar and Juniper 1992, Wiley et al. 2004). Loss of nesting habitat is particularly detrimental to the endemic insular Caribbean *Amazona* due to their extremely limited geographical ranges and inherently small populations (Reillo 2001, Wiley et al. 2004). Further, the continuing loss of nesting habitat increases both inter- and intraspecific competition for available cavities, causing some parrots to use suboptimal nest sites with a concomitant reduction in reproductive success (Wiley 1985, Prestes et al. 1997, Koenig 2001, Wiley et al. 2004). Lack of suitable nest sites has been identified as the greatest factor limiting population growth for several *Amazona*, such as the Cayman Brac parrot (*A. leucocephala hesterna*) and the St. Vincent parrot (*A. guildingii*) (Wiley et al. 2004).

Fortunately, for some *Amazona* species, proactive recovery efforts have begun. These efforts often include improvement of natural cavities and placement of artificial cavities in an effort to mitigate for a paucity of suitable nest sites (Vilella and Garcia 1995, Wiley et al. 2004). However, most such artificial cavities have been constructed on an ad hoc or trial-and-error basis, and with widely varying results (Snyder et al. 1987, P. R. Reillo, Rare Species Conservatory Foundation, personal communication). To date, there has been no consistently proven and universally applicable design for artificial nest cavities for *Amazona* parrots.

Here we describe the design, installation, and maintenance of a consistently successful artificial nest cavity developed for the critically endangered Puerto Rican parrot (*Amazona vittata*). We discuss practical solutions to common problems encountered during deployment of these structures and benefits accrued to date. A secondary tree-cavity nester with high nest-site fidelity and territoriality, the Puerto Rican parrot's nesting ecology is similar to that of most other species of *Amazona* for which comparable data exist (Reillo et al. 2000, Koenig 2001, Seixas and Mourão 2002, Wiley et al. 2004). As such, the Puerto Rican parrot also shares many of the same challenges to successful nesting faced by other species of *Amazona* (White and Vilella 2004). Thus, we also discuss the potential for adaptation of artificial nest cavities successfully used by Puerto Rican parrots to other *Amazona* management and recovery programs.

Study area

We conducted all wild nest management activities for the Puerto Rican parrot in the Caribbean National Forest (CNF), located in northeastern Puerto Rico (18°18′N, 65°47′W). Comprised of 19,650 ha of subtropical rainforest, the mountainous CNF ranged in elevation from 200–1,074 m above sea level (Snyder et al. 1987). Puerto Rican parrot nests were found mainly at elevations from 500–700 m and within the palo colorado (*Cyrilla racemiflora*) and tabonuco (*Dacryodes excelsa*) forest types (White and Vilella 2004). Rainfall is frequent, with annual precipitation ranging from 200 cm at the lower elevations to >500 cm at the higher peaks, where the relative humidity approaches 100% for most of the year (Snyder et al. 1987). Annual temperatures varied from 11–32°C, averaging 21°C (Lindsey 1992).

Methods

Design and construction

Early experiments at providing Puerto Rican parrots with artificial nest cavities identified polyvinyl chloride (PVC) as the most durable nest cavity material (Snyder et al. 1987). This is because cavities made of natural materials (e.g., wood) eventually are attacked by termites (*Reticulitermes flavipes*) and also rapidly decay in the humid CNF. The natural propensity of *Amazona* parrots to chew at nest cavity entrances and interiors also precludes use of chemically treated wood as nest cavity material. Accordingly, all current artificial nest cavities are constructed almost entirely of PVC. We used PVC industrial-grade water pipes (Industrias Vassallo, Inc., Coto Laurel, P.R.) with a wall thickness of 8–10 mm to form the primary access tube and nest chamber of the artificial nests (Figure 1). A 10-cm-wide piece of stainless-steel cage wire was attached to the inside wall of the access tube as a "ladder" to facilitate ingress and egress by parrots. The ladder extended from the upper edge of the access tube down to the upper portion of the nest chamber. The nest chamber was provisioned with a 20 cm × 20-cm hinged access door to allow for nest inspections and a removable, horizontally sliding bottom to facilitate cleaning after the nesting season. Nest chambers also were equipped with a 1.25-cm-diameter protruding "elbow" tube for optional installa-

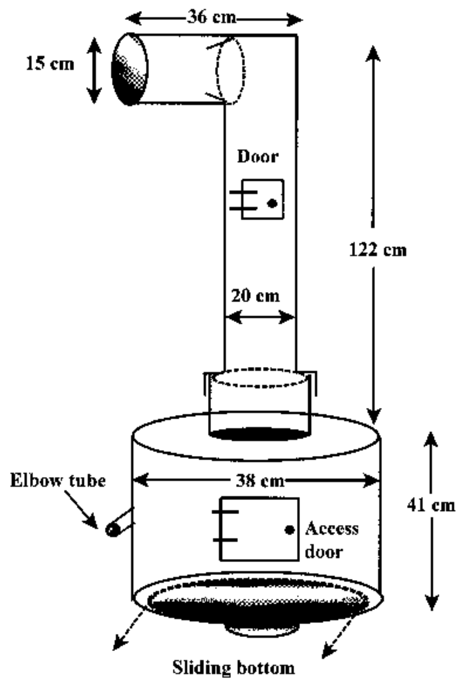

Figure 1. Schematic diagram (not to scale) of the PVC artificial nest cavity developed for Puerto Rican parrots. The elbow tube facilitates attachment of electronic monitoring devices.

tion of small electronic microphones for monitoring nesting activities (Figure 1; see White and Vilella 2004), or for installing electronic sensors to monitor temperature and humidity within the nest chamber (see Grenier and Beissinger 1999). A 15 cm × 15-cm secondary door also was incorporated midway of the access tube to further facilitate cleaning and maintenance. Both access doors were covered with an overhanging flap of rubber cut from an automobile inner tube to prevent entry of rainwater. To provide a natural-appearing nest entrance and encourage parrot use, we attached an approximately 0.3-m-long section of hollowed-out tree trunk to the PVC portion of the nest opening via 2–3 stainless-steel screws (Figure 2). All external PVC surfaces and mounting hardware are spray painted with matte-finish paint to match the color of the nest tree. A small (approximately 1-m-long) branch or liana was attached to the actual nest entrance as a horizontal perch to facilitate access by parrots (Vilella and Garcia 1995). Finally, various live bromeliads collected from the nest-site vicinity were then attached to the nest entrance to add further realism (Figure 3).

Installation and maintenance

Because the suite of variables that influence nest-site selection by parrots certainly include several

Figure 2. A complete artificial nest cavity attached to the actual nest tree. Note rubber flap covering the nest chamber access door, and the horizontal nest entrance perch. The secondary door in the access tube is sealed with silicone sealant in this example. This particular nest cavity has been used successfully by Puerto Rican parrots each year since first installed in 2001.

undetectable to researchers, the most appropriate sites for artificial nest placement are those at which parrots have nested previously. Accordingly, artificial nests for Puerto Rican parrots have most often been installed to replace a damaged or severely decayed active nest cavity. However, they also were placed throughout known parrot nesting areas at sites having similar attributes (e.g., tree species, canopy cover, elevation, vegetative associations, tree height, etc.) as active nest sites. Because of the modular design of the artificial nests, they could be transported to the installation site in 2–3 sections and assembled on-site using battery-powered hand tools and stainless-steel screws. All mated PVC surfaces were sealed with silicone sealant to prevent water entry. Once assembled, the nest cavity was hoisted into the desired position using appropriate block-and-tackle and personnel safety gear (see Jepson 1997) and secured to the actual nest tree via 5-cm-wide sections of flat aluminum stock (Figure 2). An approximately 10- to 12-cm-deep layer of dry wood chips was used in the bottom of the nest chamber as nesting material.

Maintenance of the artificial PVC cavities was simple. All nesting material was removed at the end of the nesting season, and the nest entrance sealed off with several layers of wire mesh. Prompt closure of the nest entrance avoided problems with nest usurpations by honeybee (*Apis mellifera*) swarms or other cavity-nesters during the rest of the year. Nests were then reopened at onset of the next nesting season, sprayed with disinfectant (e.g., Nolvasan®, Fort Dodge Animal Health, Overland Park, Kans.), and refilled with clean nesting material. During the nesting season, nests were periodically inspected and any soiled or wet nesting material was replaced with clean material. We replaced the wooden nest entrance approximately every 2–3 years, depending on condition.

Figure 3. Female Puerto Rican parrot at entrance of artificial nest cavity. Note wooden nest entrance and attached bromeliads.

Results and discussion

First deployed in 2001, this artificial nest cavity design has been used successfully by wild Puerto Rican parrots in all subsequent years. In fact, since 2002 all known nesting attempts by the wild population (<6/year) have occurred in PVC cavities, from which 28 chicks have fledged over the last 5 (2001–2005) breeding seasons (United States Fish and Wildlife Service, unpublished data). Although virtually all artificial cavities used by Puerto Rican parrots are at former natural nest sites, a PVC nest installed in 2002 at a new site was accepted by parrots in 2003 and and used each subsequent year (2003–2005). This nest also was the first artificial nest cavity used by wild Puerto Rican parrots at a site in which there was no previously existing natural cavity.

A primary goal of the nest cavity design was to provide adequate space for movement and prefledging exercise by nestlings. Based on audio and video monitoring of nesting activities, we have documented frequent, vigorous wing flapping by nestlings for several days prior to fledging (White and Vilella 2004). Nest chambers providing adequate space for this activity may aid parrot nestlings in developing necessary flight musculature for successful fledging.

Previously, both natural and artificial nests of Puerto Rican parrots have been plagued with frequent attempts by pearly-eyed thrashers (*Margarops fuscatus*) to usurp nests and also to enter and attack parrot eggs and nestlings (Snyder et al. 1987, USFWS 1999). By providing parrots with a deeper and darker nest cavity via the elongated access tube, we have witnessed a subsequent reduction in thrasher predation (Wiley et al. 2004). This is because thrashers are reluctant to enter deep cavities with bottoms not visible from the entrance (Snyder et al. 1987). According to Wiley et al. (2004), thrasher predation and nest competition are the primary factors responsible for the high rate of nest failures reported for the St. Lucia parrot (*A. versicolor*). Accordingly, deployment of similar PVC nest cavities also could be beneficial to the St. Lucia parrot by reducing the observed vigorous competition between thrashers and parrots for nest sites. Similarly, PVC nest cavities tailored to species-specific requirements potentially could alleviate some of the intense nest competition between the imperial parrot (*A. imperialis*) and the red-necked parrot (*A. arausiaca*) in Dominica (P. R. Reillo, Rare Species Conservatory Foundation, personal communication).

For most nesting parrots, humid tropical forests also can present special problems such as rapid decay and deterioration of nest cavities, rainwater flooding nest cavities, fungal growth within nests, and infestation of nestlings by ectoparasites (Snyder et al. 1987, Seixas and Mourão 2002, Wiley et al. 2004). Thus, a distinct advantage of our PVC nest design is the ease of maintaining a clean, dry nest cavity. Impervious to water, PVC does not wick moisture to nesting material and also can be easily disinfected to inhibit bacterial and fungal growth within the nest chamber. Further, any wet or soiled nesting material can be quickly and easily replaced. Mixing a small amount of carbamate insecticide (i.e., 5% Sevin® dust, Gulfstream, Lexington, Ky.) with the nesting material also prevents ectoparasitic infestations of nestlings (Rivera et al. 2004). We use approximately 10–15 g of carbamate powder per kg of dry nesting material.

Finally, PVC nest cavities can facilitate collection of accurate data on reproductive ecology, a fundamental requirement for correct management decisions. Because the interior of PVC nest cavities can be directly and reliably accessed, the complete nesting and chick-rearing process can be monitored either electronically, by direct nest inspections, or both (Reillo et al. 1999, Koenig 2001, White and Vilella 2004). These nests also facilitate veterinary examination and treatment of nestlings, banding of nestlings, telemetry instrumentation, and active interventions in emergency situations. However, we strongly caution researchers and managers to carefully select and safeguard the location of any artificial nest site to avoid potential detection by nest poachers (Wright et al. 2001). Artificial nest cavities for *Amazona* should not be placed in areas where unauthorized human access cannot be controlled or closely monitored.

Although no artificial nest can ever replace lost habitat, we believe that future management and recovery efforts for the increasingly endangered *Amazona* parrots could benefit from use of similar PVC nest cavities in carefully selected sites. Selective use of such nests could help reduce nest competition, mitigate local scarcities of natural nest cavities, improve nesting success, and facilitate scientific data collection. The design we have described could easily be adapted to accommodate species-specific requirements, such as differences in parrot body size and preferences for nest cavity dimensions. For the critically endangered Puerto Rican parrot, PVC artificial nests already have proven to be a valuable and effective tool for the continued recovery of the species.

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Authors' address: Puerto Rican Parrot Recovery Program, United States Fish and Wildlife Service, Box 1600, Rio Grande, PR 00745; e-mail for White: Thomas_White@fws.gov.

Thomas H. White, Jr. (far left) is a Wildlife Biologist with the U.S. Fish and Wildlife Service's Puerto Rican Parrot Recovery Program, where he has worked since 1999. From late 1996 to 1999, Tom worked as a Postdoctoral Research Associate with North Carolina State University conducting experimental releases of captive-reared Hispaniolan Parrots in the Dominican Republic. Tom has a B.S. in Natural Resources Management from the University of Tennessee at Martin, a M.S. in Wildlife Management from Louisiana State University, and a Ph.D. in Forest Resources from Mississippi State University. Tom has also worked in wildlife law enforcement, when he was an undercover wildlife officer for the Tennessee Wildlife Resources Agency from 1986 to 1992. His research interests currently are focused on the use of translocations and reintroductions in the conservation of endangered Psittacines. ***Wilfredo Abreu-González*** (second from left) is a Senior Biological Science Technician and also with the Puerto Rican Parrot Recovery Program. A native of Mariana, Puerto Rico, Wilfredo has been with the Puerto Rican Parrot Program since 1993 during which time he has been instrumental in applying novel approaches to complex field problems. Wilfredo has also served as a U. S. Fish and Wildlife Service technical advisor in cooperative international projects involving parrot research in the Dominican Republic and the Bahamas. ***Miguel Toledo-González*** (third from left) has been a Biological Science Technician with the Puerto Rican Parrot Project since 1994, when he joined the Project after 10 years with the U. S. Forest Service-Caribbean National Forest. Like Wilfredo, Miguel has also worked on cooperative international parrot projects in both the Dominican Republic and the Bahamas. ***Pablo Torres-Báez*** (far right) is a Wildlife Biologist and also with the Puerto Rican Parrot Recovery Program, where he has worked since 1991. Pablo has a B.S. and M.S. (both in Biology) from the University of Puerto Rico at Mayagüez. The combined experience of these four individuals represents over 45 years of field experience with various species of *Amazona* parrots throughout the Caribbean.