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CONSEQUENCES OF ANTENNA DESIGN IN TELEMETRY STUDIES OF SMALL PASSERINES.

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Abstract.—Entanglement and mortality of Palila (*Loxioides bailleui*), an endangered Hawaiian honeycreeper, occurred when birds were radio-tagged with transmitters equipped with a long, limp, solder-tipped antenna. Birds were found suspended in trees by their transmitter antenna on eight occasions. Although these birds eventually freed themselves or were freed by us, at least one bird died afterwards. For radio telemetry studies of small passerine species we recommend avoiding transmitters equipped with an antenna that is bulbous at the tip, >16 cm in length, limp, and shiny.

CONSECUENCIAS EN EL DISEÑO DE UNA ANTENA EN UN ESTUDIO DE RADIOTELEMETRIA PARA PASERINOS

Sinopsis.—En estudio de radiotelemetría que se llevó a cabo en *Loxiodes bailleui* se encontraron aves enredadas y una que murió. En ocho ocasiones se encontraron aves suspendidas en la vegetación atadas a esta por la larga antena con punta en forma de bulbo. Aunque algunas aves lograron liberarse y otras fueron liberadas por el grupo de trabajo, al menos una murió. Para el estudio de pequeños paserinos, utilizando radiotelemetría, no recomendamos el utilizar antenas brillantes de >16 cm de largo, con punta en forma de bulbo.

Advances in transmitter technology make radio telemetry a feasible technique for the study of many small passerine species. Factors influencing the choice of a transmitter for a small bird include cost, weight, battery longevity, signal pulse rate, frequency, sealing material, and maximum detection distance. Furthermore, there are choices about where and how to attach the transmitter to the bird. From our experiences with an endangered Hawaiian honeycreeper, the Palila (*Loxioides bailleui*), we suggest that the style and design of the antenna also is a vital consideration.

The Palila is a stocky, finch-billed honeycreeper weighing 32–45 g and found only in the subalpine forest of Mauna Kea volcano on the island of Hawai'i (Jacobi et al. 1996; Pratt et al. 1997). Palila inhabit woodland that is dominated by two tree species, mamane (*Sophora chrysophylla*) and naio (*Myoporum sandwicense*) (Scott et al. 1986; Hess et al. 1999).

Radio telemetry has been employed in a number of studies of the Palila to estimate home range size and determine movement patterns, to assess foraging behavior, to monitor re-nesting attempts after clutch removal for captive propagation, and to monitor survival and dispersal patterns of translocated birds (Fancy et al. 1993; Fancy et al. 1996; USGS-BRD, unpubl. data). Two models of transmitter and two methods of attachment have been used in Palila studies. The most common model (model A) weighed less than 2 g, functioned for ≤8 wk, and was attached interscapularly with glue (modified from Raim 1978; described by Fancy et al. 1993). The 16-cm antenna was made of 2.09 kg-test braided stainless steel with a black nylon coating. This wire is commercially available as fishing leader material from The American Fishing Wire Company (West Chester, Pennsylvania). The antenna was stiff enough to extend on a nearly horizontal plane without support. Between 1990 and the spring of 1997, model A transmitters were attached to 114 Palila with no resulting complications (Fancy et al. 1993; USGS-BRD, unpubl. data). In addition, egg fertility and hatchability was unaffected (USGS-BRD, unpubl. data).

We attached another model transmitter (model B) with figure-8 style elastic harnesses (Rappole and Tipton 1991) to 16 hatching-year Palila that were translocated in the autumn of 1997. We decided against the glue-on method because body molt during autumn would have caused the radio to fall off prematurely (Jeffrey et al. 1993). The model B transmitter, which had a similar weight and battery life as the model A transmitter, was chosen because it was less expensive and had been used effectively for translocation of Omao (*Myadestes obscurus*; J. Nelson, pers. comm.) and studies of Nightingale Reed-Warblers (*Acrocephalus luscinia*; S. Mosher, pers. comm.). The antenna was 20-cm long (4 cm longer than model A transmitters) and consisted of limp braided wire (SAVA 2014 stainless steel wire) that hung down nearly vertically from the transmitter body. To prevent the braided wire from unraveling, a small lump of solder had been added by the manufacturer to the end of the antenna.

Four Palila with model B transmitters were found suspended by their antennas on seven occasions between 26 Nov. 1997 and 5 Mar. 1998. Birds became entangled in live naio and mamane trees and a mamane snag in at least four different ways: (1) antenna wrapped around terminal leaves, (2) antenna wrapped around larger branches, (3) antenna wrapped around the fork of small branches, and (4) antenna caught under loose bark. Jackson et al. (1977) cautioned that researchers should be aware of the latter type of entanglement when working with birds that forage on tree surfaces. Each of the four Palila freed themselves from entanglement on at least one occasion; however we intervened on three other occasions to release entangled birds. When problems with the model B antenna design became apparent we attempted to remove the transmitters from all birds by strategically placing mist nests. However, the only individuals we were able to recapture where those that became snagged by their antennas in trees. On 5 Jan. 1998, a Palila was freed from a mamane tree, but escaped before the transmitter could be removed and precautionary first aid administered. The bird was found dead 36 h later. There was no evidence of predation or scavenging, and the necropsy results suggest that the bird probably died of stress from being caught in the tree (T. Work, pers. comm.).

A fifth Palila was observed hanging limply from its radio transmitter antenna 5-m high in a dense mamane tree on 5 Mar. 1998. The bird became active and began fluttering when approached. With its antenna still caught, the bird looped itself three times around a branch, the radius of this gymnastic maneuver being the length of the taut transmitter antenna. After the third loop, it freed itself and flew to a neighboring tree. Later in the same day, the bird was observed foraging normally in mamane trees. After nearly 5 mo on the bird, the antenna had developed a large hook at the tip, which became frequently but temporarily snagged on branches and leaves as it dragged behind. The bird's movements were substantially impaired.

The harness method of transmitter attachment (used with model B) has been used successfully by many field workers and was not considered to be a problem in this study. However, we observed problems with transmitters fitted with long braided wire (model B) antennas. It seems likely that birds fitted with model B transmitters became entangled on more occasions than we observed but were able to free themselves. Birds flapping and struggling while entangled could attract predators or become weakened or injured and more vulnerable to predation or starvation even if they did manage to free themselves. In addition, the shiny appearance of model B antennas may have made the birds more conspicuous to diurnal predators. The model B antenna design may have contributed to the mortality of at least 7 of 15 Palila that died before battery failure. We removed transmitters from two translocated Palila, but three others were not seen after their transmitter batteries died. Two Palila with model B radios were alive 6 mo after being translocated. After discovering the hazards of model B transmitters, we translocated 22 Palila with model A transmitters during 27 Jan–23 Apr. 1998.

We observed 16 birds equipped with model B transmitters on 305 occasions, and on eight occasions birds were caught in trees by their antenna. By contrast, the 22 birds equipped with model A transmitters were experiencing no problems on the 307 occasions that we observed them.

We suggest four design features to avoid when choosing a radio transmitter for a small passerine species: (1) a soldered, unfiled tip on the antenna, (2) an excessive antenna length (but consult the manufacturer for trade-offs with detection distance), (3) a shiny antenna wire that may attract predators, and (4) a limp antenna that may become entangled in vegetation or caught in rough or loose bark.

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