Marking Ruby-Throated Hummingbirds with Radio Frequency Identification Tags

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Note

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ABSTRACT We assessed the feasibility of marking ruby-throated hummingbirds (*Archilochus colubris*) with radio frequency identification (RFID) tags. We trapped 27 hummingbirds at feeding stations on a 2.0-ha study site. We subcutaneously implanted each hummingbird with a 0.067-g RFID tag and released it at the capture site. We deployed RFID transceiver systems at 5 feeding stations and electronically monitored tagged hummingbird activity continuously on the study site through 3 summers. Post-release relocation rate exceeded expectations based on previous leg band recovery data, and bird activity data acquisition was consistent and reliable and required minimum labor. © 2011 The Wildlife Society.

KEY WORDS bird marking, bird monitoring, hummingbirds, passive integrated transponder (PIT) tags, radio frequency identification (RFID) tags, ruby-throated hummingbird.

The minimum requirements for a successful wild animal marking system for research and management purposes include the harmless marking of the target animals, repeatability in identifying marked individuals over a time period equal to the maximum longevity of the species being marked, unfailing accuracy in reading and recording the identification codes, absence of duplicate identification codes, and minimal chance of missing an identification opportunity. Other factors influencing the utility of such a marking system include the physical practicality and cost of putting the system in place. Tarsus banding, under authority of the Bird Banding Laboratory (BBL), United States Geological Survey, was previously the only authorized technique that has proven effective for long-term monitoring of hummingbirds. Though White and Garrot (1990) reported that birds can carry 5% of their body weight without causing harmful effects, the BBL limits the weight that may be attached to birds for research or monitoring purposes in the United States to 3% of total individual body weight. There have been few attempts to attach identification or tracking devices other than leg bands to hummingbirds because of their small size. Prior to obtaining authorization from the BBL for our marking study no permits had been issued in the United States for subcutaneous implantation of radio frequency identification (RFID) tags in hummingbirds. Hummingbird leg-banding procedures carry a high risk of leg breakage, even when conducted by trained personnel (D. Bystrak, U.S. Geological Survey, personal communication). Identity verification of hummingbirds that are leg-banded requires recapturing the birds and reading tiny band numbers, which can result in errors in data recording. The labor required to continuously monitor leg-banded bird activity at a specific site is often prohibitive due to labor costs. Recapture and handling over the lifetime of a tagged bird and the potential occurrence of band reading errors are eliminated by electronic data capture using implanted RFID tags. Repeated capture has potential for altering behavior as well as increasing potential for bird injury. Thus, an automated approach to monitoring marked hummingbirds is desirable for those research circumstances that require minimal bird disturbance and absolute accuracy of time-stamped presence and absence data for specific locations. Our purpose was to test the potential utility of surgically implanted RFID tags, also known as passive integrated transponder (PIT) tags, combined with radio frequency transceivers, for marking and long-term, continuous, electronic, time-stamped detection of the presence of individual ruby-throated hummingbirds (*Archilochus colubris*) at feeding stations.

STUDY AREA

Our study site was located in Alamance County, North Carolina approximately 4 miles southeast of Snow Camp, North Carolina (35°52.01′N, 79°22.54′W). Our study area encompassed 2.0 ha of irregularly shaped, southerly sloping open hay field and mowed turf, surrounded by second growth white oak (*Quercus alba*)-dominated deciduous woodland with scattered white pine (*Pinus strobus*).

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METHODS

We placed and operated 5 hummingbird feeding stations equidistantly around the perimeter of the study site and under overhanging perimeter trees during July to September 2007. We constructed the stations of 2.54-cm square metal tubing fabricated to provide a vertical post and 2 horizontal arms, to which we attached feeders, feeder-traps, and RFID signal receiving antennas (Fig. 1). We attached the antenna such that hummingbirds were approximately 15 cm directly below it when drinking from the feeders. A wire lead connected the antenna to a Destron Fearing (Saint Paul, MN) portable transceiver system, model 2001f-ISO, which was powered by a 12-V, direct-current (DC) deep-cycle battery. We replaced batteries at 48-hr intervals. We filled the feeders with commercially available hummingbird feeding solution (Best-1® Company, Poteet, TX) and refilled and cleaned them as necessary. We equipped and operated just 2 feeding stations during April through September of 2008 but conducted no additional hummingbird trapping or tagging after 2007. We equipped and operated a single feeder station during the same period in 2009.

Prior to placing transceivers at each feeding station, we mounted a feeder trap (Hilton and Miller 2003), constructed of 1.25-cm mesh galvanized welded wire, between the horizontal arms and placed the feeder inside the trap. Each trap measured approximately 30 cm in height, width, and depth. One side of the trap was a hinged swinging (dropdown) door controlled by the observer via a monofilament line running from the door release mechanism to an observation blind 40–60 m from the trap. We placed traps and left doors open for several days to allow hummingbirds to acclimate to their presence and be accustomed to flying into the open doorway to access the feeders. During trapping efforts, as hummingbirds entered the trap to access the feeder, we released the door control line and the weighted door dropped quickly. The door was held shut by magnets attached to the bottom edge of the door frame.

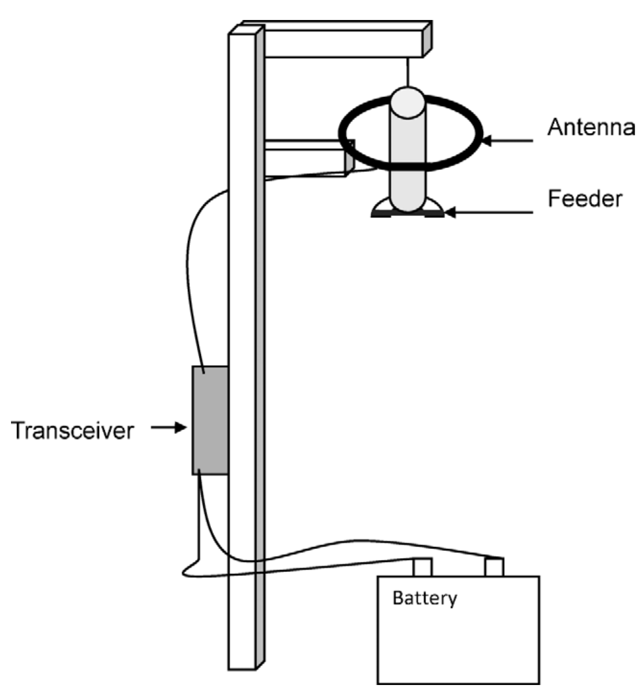

Figure 1. July 2007 to September 2009, Alamance County, NC, hummingbird feeding and monitoring station design showing feeder, antenna, transceiver, and battery.

Each trap had a small side door that permitted the observer to reach in with one hand to collect the trapped bird. We scanned each captured bird at the trap site with a Biomark® (Boise, Idaho) hand-held RFID tag reader (model FS2001) to ensure it was not a recapture and then immediately placed it into an individual brown paper bag (Hill 2002). We folded over and stapled shut the openings of the paper bags and carried them to the on-site laboratory where we implanted RFID tags.

We removed captured birds from the transport bags once inside an air-conditioned laboratory room and gave them an opportunity to drink from a feeder. All birds drank from the feeder, while held in hand, without hesitation. The tubular shaped RFID tags (BioMark) measured 5 mm in length and 1.5 mm in diameter and weighed 0.067 (±3%) g each, comprising <2% of the average male and female body weight based on data from Robinson et al. (1996). One person held the bird while a second implanted an RFID tag under the skin on the back of the neck just above the shoulders of each bird. We dampened the skin around the area of implantation with 0.5% lidocaine solution, via a cotton swab, to desensitize the skin. This also dampened the feathers, which helped smooth them aside. We implanted the tags using a trocar (Biomark) with a beveled needle gauged to allow passage of an RFID tag. We inserted a tag into the hollow trocar needle just above the bevel. We gently lifted the skin on the back of the hummingbird's neck with forceps and made a small puncture in the raised skin using the trocar and slipped the needle beneath the skin parallel to the spine without puncturing muscle tissue. We selected this location because there is ample loose skin under which to implant the tag and the tag in this location does not impede movement or flight. Once the needle was under the skin, we pushed the trocar plunger forward to eject the tag. We placed a small drop of surgical glue, which dried within 60 s, over the insertion point to close the puncture in the skin and to assure the tag remained in place. We replaced each stainless steel trocar needle with a sterilized needle for each bird. When the glue was dry we brushed the neck feathers back into place, gave the tagged bird another opportunity to drink from the feeder, and placed it back inside the brown paper bag for transport back to the feeder where it was captured. Back at the feeders, we opened the bag and allowed the bird to fly out on its own volition. We observed released birds carefully to be certain they could fly without impairment.

Our project, carried out in part to evaluate potential methodology for studying effects of air pollution on hummingbird activity, was approved by the Institutional Animal Care and Use Committee of the United States Environmental Protection Agency, Research Triangle Park, NC (Laboratory Animal Project Review no. 1006002).

Hummingbird capture and marking was authorized by Federal Bird Banding Permit 22157, issued by the United States Geological Survey, Patuxent Wildlife Research Center, Bird Banding Laboratory, Laurel, Maryland.

We monitored hummingbird feeding stations during July, August, and September 2007 and during April through September in 2008 and 2009. We mounted transceivers on 3 of the 5 stations on any given day and moved them every few days so that we monitored all 5 feeding stations for approximately equal duration during 2007. We deployed only 2 transceivers during 2008 and one during 2009. A loop antenna mounted around the feeder and above the feeding ports (Fig. 1) relayed the RFID tag signals from returning birds to the transceivers and the unique RFID numbers were detected and electronically recorded along with the date and time of day of each detection. We downloaded recorded data at each battery exchange to a notebook computer and regularly backed up the data files on separate magnetic media to assure data security. We followed the same procedures for monitoring and recording data during all 3 yr.

The transceivers stored detected tag signals in an Excel (Microsoft Corporation, Redmond, WA)-compatible file that contained, for each detection, station number, RFID tag number, date, and time. We set the transceivers to delay 5 s after detecting a given RFID tag before recording it again. This delay time is a user-defined period that can vary from 1 s to several hours. We selected 5 s to avoid a stationary bird from being recorded every second and thereby amassing an unnecessarily huge data file. Our logic was that a bird moving in and out of the antenna range (about 6 cm) in <5 s constituted a single visit. We downloaded bird relocation data to an Excel 2003 spreadsheet. We programmed a macro, written in visual basic, into the Excel spreadsheet to identify and sum consecutive 5-s visits and calculate the length of any continuous presence ≥ 5 s. Downloading the transceiver data to an Excel spreadsheet facilitated calculation of the average number of daily feeder visits/bird, total visits/bird, average feeder visit duration/bird, total time at feeders/bird per day, and grand total time spent at feeders/bird for a given monitoring period. We also calculated the number of feeding stations utilized per bird and number of times an individual moved between feeding stations. It is also possible to calculate the frequency of movements between feeders and distances traveled between feeders. Other factors that could be evaluated with this automated system, under differing distributions of equipped feeding stations, include how hummingbirds utilize patchy habitat, how they partition their time and energy expenditure pursuing localized food resources, and how dispersal of food resources affect territory size and other behaviors.

RESULTS

We captured 27 birds on the study site during 2007. Captured birds included 9 adult males, 10 adult females, 4 juvenile males and 4 juvenile females. We based age determination on plumage characteristics. We successfully implanted RFID tags with no fatalities and no apparent negative effects on all 27 birds captured. Upon release, all tagged birds appeared to fly normally. Most flew to a perch high in a deciduous tree and preened for a while before flying off and out of sight. The remainder flew directly out of sight.

We electronically recorded 13 of the 27 tagged birds (48%) at ≥ 1 feeding station during the 2007 monitoring period (Table 1). We detected 5 birds tagged in 2007 at feeding stations in 2008, including a hummingbird which we had not relocated after initial capture in 2007 (bird no. 474). We detected 4 birds again in 2009 at the single monitored feeding station, including bird number 419, which we had not redetected in 2007 or 2008. Cumulatively, we detected 55.5% of tagged birds at feeding stations after initial capture.

The number of feeder visits per bird during the monitoring periods ranged from 1 to 2,177, with the number of visits per day ranging from 1 to 160. Average duration of individual hummingbird visits ranged from 5 s to 15 s and the total time per bird spent at the feeder per day ranged from 4 s to 868 s. Total time spent at feeding stations by individual hummingbirds during any of the 3 monitoring periods ranged from 0.2 hr to 293.1 hr. The number of feeding stations utilized by individual birds ranged from 1 to 5. Five birds used one feeder, 2 used 2 feeders, 5 used 3 feeders, and 1 used 5 feeders. Individual birds that used >1 feeder changed feeders 4–96 times during the monitoring periods.

DISCUSSION

We extended monitoring over 3 summers to determine whether any birds tagged in 2007 would return to the feeders

Table 1. Age at capture, gender, and relocation records of ruby-throated hummingbirds trapped and implanted with radio frequency identification (RFID) tags in 2007 in North Carolina and electronically monitored at feeders for 3 consecutive summers.

Tag no.	Sex	Age	2007	2008	2009
494	M	Ad			
401	F	Ad			
430	F	Ad	×		
457	M	Juv	×	×	×
479	M	Juv	×		
469	M	Ad			
453	F	Ad			
445	F	Juv	×		
458	M	Ad	×	×	
411	M	Ad	×		
449	F	Ad	×		
439	F	Ad			
413	M	Ad	×		
424	F	Ad			
423	M	Juv	×	×	×
463	F	Juv	×	×	
459	M	Juv	×		
464	F	Juv			
442	F	Ad			
448	M	Ad	×		
419	F	Ad			×
469	M	Ad			
474	F	Ad		×	×
462	F	Juv			
486	M	Ad			
426	M	Ad			
467	F	Ad	×		

over multiple years and, thereby, verify that hummingbirds carrying RFID tags successfully completed their round-trip migration between breeding and wintering grounds. The 2008 and 2009 monitoring also provided opportunity to relocate tagged birds that were not relocated after release in 2007. Hilton and Miller (2003) captured and marked 1,327 ruby-throated hummingbirds with leg bands in SC during 1984–2000. After the initial capture year, 17% of these banded birds were recaptured at least once. Finlay (2007) captured and banded 3,453 rufous hummingbirds (*Selasphorus rufus*) at his 4 most consistently monitored trapping stations over a 9-yr period in British Columbia. The rate of recapture after the capture year averaged across the 4 banding sites was 14.3% of total captures. Charrette and Rousseau (University of Sherbrooke, Québec, unpublished data) studied hummingbird foraging pattern and patch use by externally attaching RFID tags to hummingbirds with glue and monitored hummingbirds with leg bands at a separate site. Those authors concluded that RFID-tagged birds were redetected 1.5 times more frequently than leg-banded birds. The electronic redetection rate of individual birds relocated at least once after the initial tagging year in our study was 26%. We intend our data to provide examples of the type and volume of data acquisition possible when hummingbirds are marked with implanted RFID tags. The amount of personnel time necessary to collect our data was <1 hr per day once we completed trapping and tagging. Conducting continuous activity monitoring for this duration via repeated captures and reading leg band numbers would be difficult, time intensive, and problematic because of the human time limitation as well as the effects of repeated capture on banded hummingbirds. Charrette and Rousseau (unpublished data) demonstrated that glued RFID tags remained attached to the hummingbirds for short periods but nonetheless concluded "PIT tags offer research opportunities of untapped proportions with regard to spatially explicit foraging ecology of small bird species that strongly depend on localized food sources." However, it should also be recognized that this technology would be of limited added benefit to studies requiring the collection of physiological factors over time such as breeding status of females, seasonal body weight changes, or time of molting. The cost of the electronic equipment may also be limiting for very short-term studies. The transceivers we used cost approximately $2,850 each and RFID tags of the size we used cost approximately $5 each. Electronic peripherals added $375. Materials for establishing each trapping and monitoring station cost approximately $200. Our investment per trapping and monitoring station was $3,175 plus the cost of RFID tags. We purchased 100 tags for this study for $550. Such equipment costs may be practical only for long-term efforts.

Management Implications

The outcome of our experimental tagging suggests hummingbirds, and probably other small bird species, can be subcutaneously implanted with RFID tags with few, if any, injuries or negative effects. Radio frequency identification tags have no known limit to the duration the tag number can be read by a transceiver, allowing long-term collection of survival and activity data, which can be used to generate information such as migration routes and timing, feeding frequencies, habitat patch preferences, and use patterns. There are also no limitations to the number of RFID tags that can be deployed in a given area or nation-wide and essentially no chance that one would encounter a duplicate tag number. Implanting RFID tags has the potential for significantly increasing not only the amount of data but also the accuracy of data that can be collected at specific locations on individual bird activity and behavior without repeated captures, which reduces risk to subject birds. Implanting RFID tags also holds promise for substantial cost reduction for long-term bird presence–absence data collection at specific locations.

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