Notes

Behavioral Response of Bats to Passive Integrated Transponder Tag Reader Arrays Placed at Cave Entrances

Eric R. Britzke,* Mark W. Gumbert, Matthew G. Hohmann

E.R. Britzke
U.S. Army Engineer Research and Development Center, Environmental Laboratory, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180

M.W. Gumbert
Copperhead Environmental Consulting, Inc., 11641 Richmond Road, Paint Lick, Kentucky 40461

M.G. Hohmann
U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory, P.O. Box 9005, Champaign, Illinois 61826

Abstract

An increasingly popular mark–recapture method to study the ecology of bats is the use of passive integrated transponder (PIT) tags. Deployment of PIT reader arrays at entrances to caves and mines can yield insight into bat behavior during swarming, winter activity, and emergence. This application has the potential to address questions about bat activity at cave and mine entrances in response to white-nose syndrome or bat seasonal movements; however, no studies have examined the response of bats to these arrays. We describe bat response to placement of PIT tag reader arrays using camcorders and supplemental infrared illuminators at three cave entrances near Bloomington, Indiana, during spring 2006. A random subset of 5-min periods was viewed and bat behavior was classified. Circling represented $>$70% of all behavior noted for two caves but only represented approximately 30% of behavior at the third cave. Proportions of observed activity that resulted in contacts or landings were consistently low across the three caves ($\bar{x}$ = 1.34%; range 0.5–3.0%), with most contacts causing bats to simply change course and fly away. Based on our observations, positioning reader PIT tag reader arrays at cave entrances to passively recapture PIT tags does not limit bat movements. However, video monitoring during initial sampling efforts of future projects should be conducted to verify appropriate placement and configuration of PIT tag reader arrays. This research provides data illustrating the lack of significant impact in using PIT tag reader arrays at cave entrances, thereby opening up the potential use of this technology to address issues of bats ecology that cannot be obtained with other marking techniques.

Keywords: bats; Indiana bat; behavior; passive integrated transponder (PIT) tags

Received: August 9, 2012; Accepted: December 10, 2013; Published Online Early: January 2014; Published: June 2014

Citation: Britzke ER, Gumbert MW, Hohmann MG. 2014. Behavioral response of bats to passive integrated transponder tag reader arrays placed at cave entrances. *Journal of Fish and Wildlife Management* 5(1):146–150; e1944-687X. doi: 10.3996/082012-JFWM-065

* Corresponding author: Eric.R.Britzke@usace.army.mil

Introduction

Numerous methods have been used to study the ecology of bats, including light-tagging, radiotelemetry, and wing banding (Barclay and Bell 1988; Kunz and Weise 2009). Light-tagging (attachment of a cyalume light stick to a bat and then releasing it) and radiotelemetry provide valuable data on the movements of bats, but these data can only be collected over a relatively short period and are extremely labor-intensive.

Despite widespread use of banding, recovery rates are extremely low for most species, providing limited information about many aspects of species' behavior and ecology (Ellison 2008).

An increasingly popular method of mark–recapture in wildlife studies is the use of passive integrated transponder (PIT) tags (Gibbons and Andrews 2004). Passive integrated transponder tagging involves subcutaneously injecting a uniquely coded glass-encapsulated tag into the animal. Instead of operating on battery power, PIT tags are activated when they come in proximity to an antenna and reader, thereby providing an opportunity to collect long-term monitoring and movement information. Passive integrated transponder tags have advantages over bands in that they cannot be chewed off by the bat, get caught and pulled off, or create an infection in the wing (Ellison 2008). Although injection sites may become infected or PIT tags can be lost before the wound is finished healing, proper use by an experienced researcher can minimize these risks (Kunz and Weise 2009). Marked animals can be scanned with a hand-held antenna upon recapture or can be detected without recapture if an antenna is placed in the path of a marked individual. The ability to sample bats without the need for recapture increases the amount of data that can be collected from a marked bat and reduces the need to handle bats for successive recaptures. The latter is important because it minimizes the issue of trap bias inherent in banding studies (Kunz and Brock 1975; Winhold and Kurta 2008).

Use of PIT tags to study bat behavior and ecology has increased over the past two decades (e.g., Kerth and Konig 1996; Kerth and Reckardt 2003; Garroway and Broders 2007; Adams and Hayes 2008; O'Shea et al. 2010). Many temperate bats hibernate in caves and mines during the winter to survive the period of low prey abundance. During early spring, bats emerge from hibernation and migrate to their summer range. A potential application of this technology is placement of a PIT tag reader array at a cave or mine entrance to passively sample bats as they enter and exit. With the emergence of white-nose syndrome, an infectious disease that has recently affected hibernating bats in the eastern United States and resulted in very high mortality rates (Lorch et al. 2011), the need to understand bats' behavior at caves and mines has greatly increased. Evaluating the potential impact of novel conservation and research tools is prudent before widespread use. We investigated the bat response to PIT tag reader arrays positioned at three cave entrances during spring 2006 as part of a larger project studying seasonal movements of Indiana bats (*Myotis sodalis*).

Study Area

We selected three caves (Clyfty Cave in Greene County and Grotto and Saltpeter caves in Monroe County) near Bloomington, Indiana, for monitoring of bat activity between 28 March and 8 April 2006. These sites were selected due to size of the cave opening, ability to access the site with the necessary equipment, and landowner permission. The number of bats present during hibernation among the three caves varied: Saltpeter Cave (<200), Clyfty Cave (<1,000) and Grotto Cave (>12,500; Brack et al. 2003). All three caves had the same four bat species present (Indiana bat; little brown *Myotis lucifugus*; big brown *Eptesicus fuscus*; and tricolored bat *Perimyotis subflavus*). The broader landscape surrounding our study area consisted of a matrix of rural housing, varied agricultural practices, and public and private forestland. The primary forest cover type lies within the eastern deciduous forest as described by Braun (2001). Weather was variable throughout the sampling session with temperatures ranging from a low of 1°C to a high of 25°C, with periods of heavy precipitation.

Methods

In February 2006, we visited all cave entrances to obtain measurements and to determine placement of the PIT tag reader arrays. We then constructed a wooden frame made from 2 × 4's to match the physical dimensions of each cave entrance and to maximize the number of square waterproof pass-through readers (ANT-FS2-20-001, with inside dimensions of 50.8 × 50.8 cm; Biomark, Boise, ID) that would fit within the space. Each frame was constructed on-site in March to custom fit the PIT tag reader arrays to each cave.

The number and placement of readers in the PIT tag reader arrays depended on the size and shape of the opening to be sampled. A double layer of bird netting was drawn tight across the remaining openings and stapled to the wooden frame. Bird netting helped funnel bats through the readers and was stretched taut to minimize the chance of bats becoming entangled, while still allowing for airflow through the PIT tag reader array. We monitored all reader PIT tag reader arrays to assist bats in the event they became entangled in the bird netting. At Grotto Cave, we placed three readers at the cave entrance (0.8 × 3.9 m) where the opening drops down into the ground at a 45° angle (Figure 1A). This configuration allowed for 25% of the available flight space to be used by bats. Clyfty Cave has two entrances: a flowing stream exits one opening and the other opening is relatively dry. Presence of the flowing stream precluded sampling of this entrance, so we only deployed the PIT tag reader array at the other entrance. We placed two PIT tag readers oriented diagonally from one another (rather than side by side as in the other caves) approximately 1 m in front of the constricted area where the passage narrows (0.6 × 1.2 m; Figure 1B), thereby allowing 14% available flight space. Saltpeter Cave is a sink-like setting with a stream flowing into the cave entrance. A PIT tag reader array with four readers was placed in an "L" configuration at the entrance to the cave (1.1 × 3.9 m; Figure 1C), allowing 18% available flight space. We separated readers by a minimum of 40.6 cm when positioned side by side, or we placed them diagonally from one another to prevent interference with the electromagnetic communication between the PIT tags and readers. The percentage of flight space available was calculated by measuring the opening within all readers divided by the total area of the entrance.

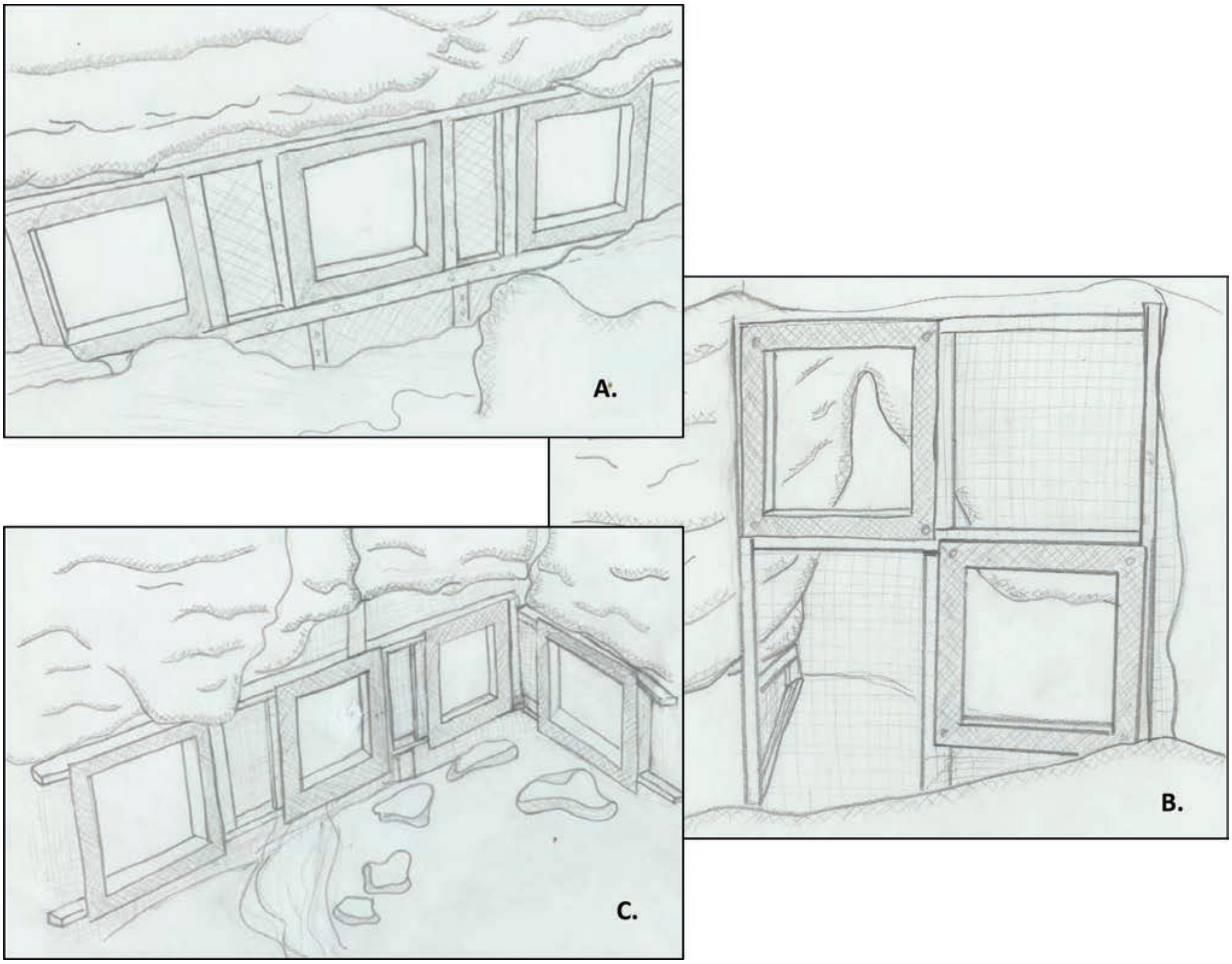

Figure 1. Sketches depicting arrangement of PIT tag reader arrays in each of the three caves sampled as part of this study during spring 2006: Grotto Cave (**A**), Clyfty Cave (**B**), and Saltpeter Cave (**C**). Portions of the cave opening on either side of the gate are not depicted.

Bat behavior was recorded using camcorders (Handycam DCR HC42; Sony) powered by automotive jumpstart DC power sources (Mity Mite PS-12A). Recording occurred in concert with a minimum of three supplemental infrared (IR) illuminators (jWIN JV-AC156 Infrared Night Vision Lamps and a Wildlife Engineering IRLamp6) to view bat behavior more clearly. Illuminators were powered by 12-V batteries (Power Sonic). Recording was initially conducted for the entire night but was then reduced to the first 3 h after sunset because the majority of bat activity at the caves occurred during this period.

Video recordings for each night at each cave were subsampled by randomly selecting six 5-min periods for analysis. Sampling was stratified so that two randomly selected periods occurred during each hour of sampling. Selected time periods were viewed, and bat behavior was classified using six categories following Spanjer and Fenton (2005): 1) circling, 2) fly-retreat (i.e., when a bat abruptly changes direction), 3) pass, 4) chasing, 5) contacts, and 6) landing. A weave behavior was added to describe a bat that passes through a reader and then back through in the opposite direction in close succession. Because different types of contacts were observed, this category was divided up into the following subgroups:

- Wing-tip brush: wing of bat brushes along the edge of the reader, frame, or bird netting
- Glance: bat slides across the bottom or top of the reader when passing through it
- Bat to bat: two bats come into contact while in flight
- Bird netting: bat collides with the bird netting
- Antenna/frame: bat collides with reader or frame

All behavioral data were compiled and standardized so that behavior levels represented the amount of each specific behavior activity occurring per hour.

Results

The number of days and hours of video recorded at caves varied due to weather, number of bats in each cave, and overall bat activity at each cave: Grotto Cave, 20 h over 12 d; Clyfty Cave, 22 h over 8 d; and Saltpeter Cave, 16 h over 7 d. Bat behavior near arrays varied

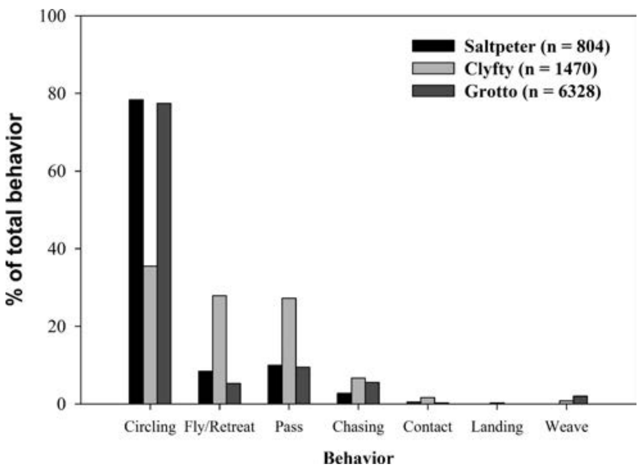

Figure 2. Relative percentage of seven behaviors noted during video analysis of bat activity near a passive integrated transponder tag reader array at three caves in Indiana during spring 2006.

greatly among the three caves. Circling represented >70% of all behavior noted for Saltpeter and Grotto caves; however, at Clyfty Cave, the amount of circling, fly retreat, and passes were each approximately 30% of the total behavior recorded (Figure 2). Contacts represented <1% of all observed behaviors for Grotto and Saltpeter caves but represented 3% for Clyfty Cave (Figure 2; Table S1, Supplemental Material). Although landing on bird netting was the most common contact type, we observed no occurrences of bats becoming entangled when they landed on the bird netting.

Discussion

This study describes bat behavior while a PIT tag reader array was in place. Although obtaining behavioral data in the absence of the PIT tag reader array would have allowed us to make direct comparisons, this was not possible because spring emergence occurs over a much shorter duration and is more variable than fall swarming. This variation and low number of suitable nights would have made any comparisons difficult to interpret. Although we were unable to make direct comparisons on the response of bats to the PIT tag reader arrays, observations while conducting exit counts at cave entrances suggest that the high proportion of circling activity of bats at PIT tag reader arrays observed in this study is consistent with emergences at caves and mines with entrance gates (E.R.B., unpublished data).

Proportions of contacts with the PIT tag reader array were similar among the three caves and were slightly lower than the rate of 2% noted by Spanjer and Fenton (2005) who used real-time observations at bat-friendly cave gates during fall swarming. Our observations differed from those by Spanjer and Fenton (2005) because we were able to review video tapes multiple times and at slower speeds in an attempt to document contacts; they documented behaviors while positioned at the cave. This heightened level of inspection likely resulted in detection of slight contacts that might have been missed by Spanjer and Fenton (2005). Thus, contact rates with PIT tag reader arrays are likely lower than those that have been deemed acceptable in cave-gating projects. In addition, the lack of entanglements with the bird netting despite numerous encounters suggest that there is no need for constant monitoring of PIT tag reader array in future work if the arrays and netting are designed and deployed in the same manner. Variation in the percentage of observed behaviors between Clyfty Cave and the other two caves may be a result of the structure of the cave entrance as well as the design and placement of the PIT tag reader array. Placement of the PIT tag reader array at Clyfty Cave was selected to minimize the obstruction of the flight path as bats exited the constricted area. However, video recording showed that once bats passed through the tight passage, there was little room for circling with the PIT tag reader array in place. Thus, we saw an increase in fly retreats and passes but a decrease in circling. In addition to the restricted space, the majority of bats in the video appeared to be big brown bats. Lack of flight space at the PIT tag reader array and the presence of relatively large bats that have lower maneuverability may account for the lack of circling and the increase in landing on the bird netting at Clyfty Cave. Similarly, Spanjer and Fenton (2005) reported that bats seemed more able to avoid an angle-iron gate at the entrance rather than one inside the cave. Analysis of video recordings early in a project can be used to determine whether the placement of the reader array is appropriate or may need to be moved to minimize contacts and landings.

This study was conducted during the spring emergence at these three caves. Because PIT tag reader arrays are likely going to be deployed during the fall swarm (if not year-round), future efforts should investigate the effects of the placement on PIT tag reader array on fall swarming behavior. The large amount of activity present at the cave entrance during the fall swarm may enhance the chances of a negative effect of the PIT tag reader array at the entrance. In addition, the longer duration of activity during the fall swarm would allow comparative analyses of the same site with and without the reader present. This would provide a more direct assessment of the impact of the PIT tag reader array.

Bats use openings in the reader arrays much the same way they have been observed using open doors in angle iron gates or fence gates. Overall, PIT tag reader arrays designed to passively recapture individually marked bats at cave and mine entrances do not seem to be a barrier to bat movements. Factors such as size of the entrance, structure of the opening, and the placement of the reader array should be incorporated into future applications using this technique to minimize any potential impacts on bats. As placing PIT tags in bats becomes more prevalent, use of readers and reader arrays at cave entrances will likely become a more common, less stressful recapture method. Their use will provide valuable information about the movements of bats between seasons and behavior of bats at caves and mines that, until now, has been unobtainable.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

Table S1. Excel file containing data on the bat behaviors observed in response to PIT tag reader arrays at the entrances to three caves in Indiana during spring 2006.

Found at DOI: http://dx.doi.org/10.3996/082012-JFWM-065.S1 (20 KB XLS).

Reference S1. Ellison LE. 2008. Summary and analysis of the U.S. Government bat banding program. U.S. Geological Survey Open-File Report 2008-1363.

Found at DOI: http://dx.doi.org/10.3996/082012-JFWM-065.S2; also available at http://pubs.usgs.gov/of/2008/1363/pdf/OF08-1363_508.pdf (1.3 MB PDF).

Acknowledgments

The U.S. Army Corps of Engineers, Construction Engineering Research Laboratory provided financial and technical support for this project. C. Hansen designed the supplemental power system for the digital readers and fitted the weatherproof cases with external recharging connectors. P. Frank assisted in the construction of the PIT tag reader arrays. S. Johnson provided invaluable assistance with cave selection, contacting property owners, and PIT tag reader array placement. L. Pruitt and A. King provided guidance on project implementation. D. Everton, K. Dunlap, M. Wright, and M. Lawrence provided cave access. D. Foster, J. Hawkins, C. Leftwich, K. McDonald, P. Roby, and P. Sewell were instrumental in transporting the heavy equipment allowing for data collection for this project. P. Roby and N. Beane, three anonymous reviewers, and the Subject Editor provided constructive comments on an earlier version of this manuscript.

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

References

Adams RA, Hayes MA. 2008. Water availability and successful lactation by bats as related to climate change in arid regions of western North America. Journal of Animal Ecology 77:1115–1121.

Barclay RMR, Bell GP. 1988. Marking and Observational Techniques. Pages 59–76 in Kunz TH, editor. Observational techniques. Ecological and behavioral methods for the study of bats. Washington, D.C.: Smithsonian Institution Press.

Brack V Jr, Johnson SA, Dunlap RK. 2003. Wintering populations of bats in Indiana with emphasis on the endangered Indiana myotis, *Myotis sodalis*. Proceedings of the Indiana Academy of Science 112:61–74.

Braun EL. 2001. Deciduous forest of eastern North America. Caldwell, New Jersey: The Blackburn Press.

Ellison LE. 2008. Summary and analysis of the U.S. Government bat banding program. U.S. Geological Survey Open-File Report 2008-1363. (see *Supplemental Material*, Reference S1, http://dx.doi.org/10.3996/082012-JFWM-065.S2); also available: http://pubs.usgs.gov/of/2008/1363/pdf/OF08-1363_508.pdf (January 2014).

Garroway CJ, Broders HG. 2007. Nonrandom association patterns at northern long-eared bat maternity roosts. Canadian Journal of Zoology 85:956–964.

Gibbons JW, Andrews KM. 2004. PIT tagging: simple technology at its best. BioScience 54:447–454.

Kerth G, Konig B. 1996. Transponder and an infrared-video camera as methods used in a field study on the social behaviour of Bechstein's bats (*Myotis bechsteinii*). Myotis 34:27–34.

Kerth G, Reckardt K. 2003. Information transfer about roosts in female Bechstein's bats: an experimental field study. Proceedings of the Royal Society London B 270:511–515.

Kunz TH, Brock CE. 1975. A comparison of mist nets and ultrasonic detectors for monitoring flight activity of bats. Journal of Mammalogy 56:907–911.

Kunz TH, Weise CD. 2009. Methods and devices for marking bats. Pages 36–56 in Kunz TH, Parsons S, editors. Ecological and behavioral methods for the study of bats. 2nd edition. Baltimore, Maryland: Johns Hopkins University Press.

Lorch JM, Meteyer CU, Behr MJ, Boyles JG, Cryan PM, Hicks AC, Ballmann AE, Coleman JTH, Redell DN, Reeder DM, Blehert DS. 2011. Experimental infection of bats with *Geomyces destructans* causes white-nose syndrome. Nature 480:376–378.

O'Shea TJ, Ellison LE, Neubaum DJ, Neubaum MA, Reynolds CA, Bowen RA. 2010. Recruitment in a Colorado population of big brown bats: breeding probabilities, litter size, and first-year survival. Journal of Mammalogy 91:418–428.

Spanjer GR, Fenton MB. 2005. Behavioral responses of bats to gates at caves and mines. Wildlife Society Bulletin 33:1101–1112.

Winhold L, Kurta A. 2008. Netting surveys for bats in the Northeast: differences associated with habitat, duration of netting, and use of consecutive nights. Northeastern Naturalist 15:263–274.