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Tools and Technology

A Method for Improving the Reliability of Sound Broadcast Systems Used in Ecological Research and Management

JONATHON J. VALENTE,[1] *Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331, USA*

CHRISTA L. LEGRANDE, *Department of Environmental and Forest Biology, State University of New York College of Environmental Science and Forestry, Syracuse, NY 13210, USA*

VINCENT M. JOHNSON, *Fisheries, Wildlife, and Environmental Studies Department, State University of New York Cobleskill, Cobleskill, NY 12043, USA*

RICHARD A. FISCHER, *United States Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, MS 39180, USA*

ABSTRACT Automated sound broadcast systems have been used to address a variety of ecological questions, and show great potential as a management tool. Such systems need to be reliable because treatments are often applied in the absence of a human observer and system failure can cause methodological ambiguity. During the breeding seasons of 2012 and 2013, we used a sound broadcast system previously described by Farrell and Campomizzi (2011) in an experiment evaluating the use of post-breeding song in forest-bird habitat selection in southern Indiana, USA. This system incorporates a portable compact disc (CD) player where the play button is permanently depressed using manual compression so that when a timer connects an electrical current to the unit, the CD player automatically starts. Despite exhaustive efforts to find a reliable way to manually compress the play button on numerous CD player models, play button failure was the most significant source of broadcast system failure (88%) in 2012. We attempted to resolve this problem in 2013 by removing the need for manual compression and soldering the play button contact poles on each CD players' integrated circuit boards. Though we did experience broadcast system failures during <5% of treatment periods in 2013, none of those were attributable to play button failure. By removing all possibility of failure from manual play button compression we improved our system reliability. Thus, soldering the CD player play button on such broadcast systems represents a methodological improvement that can be used by researchers and managers interested in sound broadcast. © 2014 The Wildlife Society.

KEY WORDS bird song, CD player, momentary action pushbutton switch, play button depression mechanism, sound broadcast system.

Sound broadcast systems serve a variety of purposes in ecological research. They have been used to answer questions about perceived predation risk on reproductive performance (Eggers et al. 2006, Zanette et al. 2011), movement ecology in fragmented landscapes (Sieving et al. 1996, 2000, 2004; Desrochers and Hannon 1997; Bélisle and Desrochers 2002), habitat selection (Doligez et al. 2002, Ward and Schlossberg 2004, Nocera et al. 2006, Fletcher 2007, Betts et al. 2008), heterospecific interactions (Diego-Rasilla and Luengo 2004, Fletcher 2007, Pupin et al. 2007), impacts of noise pollution (Bee and Swanson 2007), and to explore mechanisms driving species distribution patterns (Fletcher 2009). Additionally, audio broadcasts can be incorporated into survey protocols to improve detectability for some organisms (Gibbs and Melvin 1993, Conway and Simon 2003, Kubel and Yahner 2007, Ichikawa et al. 2009), and manipulation of species responses to conspecific attraction shows great promise as a management tool (Ward and Schlossberg 2004, Ahlering and Faaborg 2006).

In many instances, application of auditory experimental or management treatments is done most efficiently using automated systems that can be programmed to operate without a human present (Ward and Schlossberg 2004, Fletcher 2007, 2009; Betts et al. 2008; Zanette et al. 2011). Drawing correct and useful conclusions from such studies is contingent on broadcast treatments being applied correctly, making the reliability of automated systems a critical consideration. System failures lead to heterogeneity and ambiguity in treatment applications, and unreliable systems need to be visited with greater frequency, resulting in a loss of money and man hours.

Farrell and Campomizzi (2011) presented a description of a sound broadcast system that incorporated a portable compact disc (CD) player on which the play button was permanently depressed so that when a timer switch connected an electrical current to the unit, the CD player automatically started. These authors describe using "a combination of adhesive

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[1]*E-mail: jonathon.j.valente@gmail.com*

tape, wooden dowels, and rubber stoppers to set the play button in the on position" (Farrell and Campomizzi 2011:463). During field tests with comparable broadcast systems, we attempted to use similar tools for our play button depression mechanisms (PBDM), yet we were unable to develop a reliable method of securing the play buttons in the on position using compression. As such, PBDM failure was by far our greatest source of system failure, and we sought to develop a more reliable method of initiating playback for our experiments by bypassing the need for a PBDM on the CD player component. As part of a broader experiment evaluating the use of post-breeding song in breeding habitat selection by wood thrush (*Hylocichla mustelina*) and Kentucky warblers (*Oporornis formosus*) in forest tracts of southern Indiana, USA, we evaluated whether soldering the electrical play button connection would be a more reliable method of initiating playback in broadcast systems regulated by a timer than consistently applying pressure to the play button.

STUDY AREA

Our study area encompassed approximately 750,000 ha of land in the central hardwoods region of southern Indiana, specifically within Big Oaks National Wildlife Refuge, Naval Surface Warfare Center Crane, Martin State Forest, and the Lost River Tract of Hoosier National Forest. This region was dominated by corn and soybean agriculture and remnant tracts of temperate broadleaf and mixed forests. The mean annual rainfall in southern Indiana was approximately 119 cm (Indiana State Climate Office 2002), and mean annual temperatures ranged from 6° C in winter to 18° C in summer (National Climatic Data Center 2011).

METHODS

During the 2012 and 2013 breeding seasons, we deployed post-breeding song broadcast systems at point-count stations (34 in 2012 and 24 in 2013) previously unoccupied by target species (wood thrush and/or Kentucky warblers). Treatments were applied between 28 June and 23 August each year in order to experimentally test whether post-breeding song would attract future breeders. In ideal circumstances, treatment sites received between 48 and 56 hours of song broadcast (8 hr/day) in intervals of 6–7 days based on the life of the batteries (12 V 12 A Energy Power Absorbent Glass Mat battery; Energy Battery Group, Atlanta, GA). Our study design incorporated paired control sites, though information about those is tangential to our focus and will not be discussed further.

All broadcast systems contained 1 of 2 portable CD player models (INSIGNIA NS-P4112 or INSIGNIA NS-P113; INSIGNIA Products, Richfield, MN). The play buttons on both CD player models utilize a momentary action pushbutton switch that, when depressed, connects power required to play the CD to 4 contact poles on the integrated circuit board via a convex disk of flexible metal (Fig. 1). In 2012, we rotated 18 broadcast systems among treatment sites on a bi-weekly schedule, and each time a unit was placed at a treatment site, a trained technician used a combination of adhesive tape, rubber bands, metal pins, square keys, sticky tack, glue, and pieces of eraser to manually depress and secure the CD player play button. Methods for permanently depressing the play buttons varied temporally as we attempted to identify a reliable solution, and varied among CD players because of subtle differences in model design.

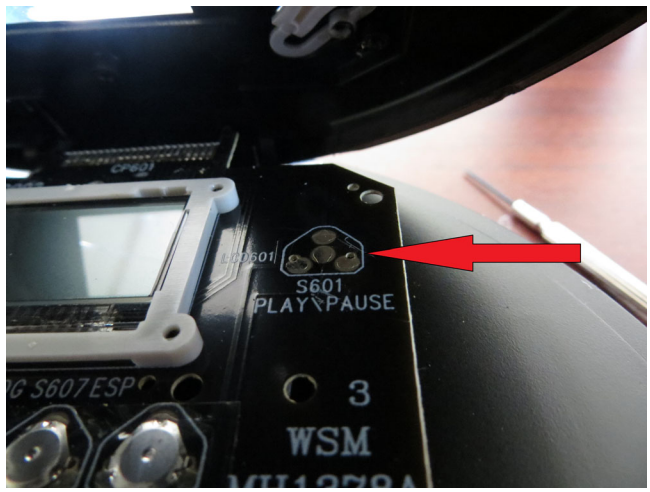

Figure 1. A close-up image of the exposed upper integrated circuit board of a CD player (INSIGNIA NS-P4112; INSIGNIA Products, Richfield, MN). When the 4 contact poles (indicated by red arrow) associated with the play button are connected by an electrically conductive medium, the unit begins playing.

In summer of 2013, we increased the number of broadcast systems to 24 and did not rotate them among sites. To eliminate the need to apply manual pressure to CD player play buttons, we applied a thin layer of electrically conductive rosin soldering flux (RadioShack Corporation, Fort Worth, TX) to the contact poles and connected them with solder using a Weler soldering iron (Cooper Hand Tools, Apex, NC) prior to system deployment (for detailed instructions, see Supporting Information, available online at www.onlinelibrary.wiley.com). This connection allows a constant electrical current to flow among contact poles to create a closed contact system, which is electrically identical to having the play button depressed at all times (Eaton Corporation 2007). Both PBDMs and soldering ensure that the 4 poles are connected when the CD player receives power, but by soldering the connection we removed virtually all possibility of manual failure (e.g., play button deformation, PBDM dislodging, rubber bands stretching, adhesives failing, or human error in application). We then re-assembled the CD players to their original condition and incorporated them as components in the broadcast systems. All other components used in the treatments were identical for each year.

We visited treatment sites once every 6 or 7 days to change the batteries and rotate the units (2012 only), and considered each period between battery changes (treatment period) as the experimental unit for our analyses. This is a logical temporal unit because a broadcast system operator would ideally be able to deploy a system and be confident that the components would continue working until the battery was scheduled to expire. When convenient, we made additional visits to treatment sites to verify that the units were working as intended.

If a unit was visited before the battery was scheduled to expire, and the unit was not playing appropriately, a technician thoroughly assessed all components, documented the reason for failure, and fixed the source of failure. When units were visited after the battery had likely expired, the technician connected a new, charged battery, and then assessed the status of the unit. Any broadcast system malfunctions that could not be explained by a dead battery were also documented. If the playback unit or one of its components failed at least once during a treatment period, whereby bird song was not being broadcasted as intended, the treatment was considered a failure; whereas, if the unit continued broadcasting until the battery expired, it was considered a success. Prior to analyses, we eliminated all failures resulting from human error (i.e., avoidable situations in which the broadcast system was not properly assembled by field personnel) and limit our discussion to treatment periods that were disrupted by component failure.

RESULTS

Our sample size was 100 treatment periods in 2012, and we experienced 8 treatment period failures, 7 (88%) of which were specifically attributable to PBDM failures. All PBDM failures occurred when rubber bands stretched or snapped, depression components moved slightly so that pressure was no longer being applied in the correct area, or the CD player became warped. The only other failure occurred when the micro Universal Serial Bus (USB) speaker charger stopped functioning in one unit. In 2013, our sample size was 170 treatment periods, and we experienced 8 total failures, none of which were attributable to the CD player play button. All failures were due to malfunction of other broadcast system components, including 1 speaker, 3 speaker chargers, 1 12-V direct current (DC) power outlet y-adapter, and 3 CD player power jacks. Therefore, the soldering method had a 100% success rate while units were deployed in the field.

DISCUSSION

In 2012, when all of our playback systems were activated using manual depression (PBDMs), play button failure was by far the most significant source of treatment interruption. In 2013, we were able to completely eliminate this problem by soldering the contact poles that are connected when the play button is depressed, resulting in a much more reliable broadcast system.

We encountered 2 primary issues that made manual play button depression challenging. First, each CD player model (we experimented with several additional models before selecting those we used in the field) has a unique design that requires a unique solution for depressing the play button, meaning there is no ubiquitous methodology. Second, because the play button is designed to spring back after depression, applying too little pressure means the unit will not start playing as intended, and applying too much pressure can result in deformation of multiple pieces (e.g., the plastic play button, the convex metal disk, and the CD player shell itself) or physically prevent the CD from turning. In addition to the materials described above, we tried numerous other methods for securing CD player play buttons in the laboratory (including manual clamps, glue, rubber stoppers, and weighted pressure), but were never able to generate an infallible solution until we eliminated the need for manual pressure altogether.

There are 3 explanations for why we saw a greater number of electronic component failures in the second season. First, it is possible that by tampering with the internal circuitry on the CD players, we interfered with other internal mechanisms, causing the DC power jacks to eventually fail on 3 of them. However, we believe that this scenario is very unlikely, given that every CD player that we disassembled, soldered, and put back together ($n = 27$) worked as intended initially, and none of them failed until after they had been used in the field for several weeks. Second, our study region received more than twice as much precipitation in the summer of 2013 (approx. 32.8 cm) as in the summer of 2012 (approx. 16.4 cm; Indiana State Climate Office 2013). It seems likely that environmental moisture was responsible for many of the failures we endured with CD players and other electronic components in the second year, particularly given that others have identified moisture as a primary cause of failure in similar systems (Farrell and Campomizzi 2011). Third, approximately 75% of the playback unit components (including 18 of 27 CD players) we used in 2013 had been previously used in the field in 2012. As such, some may have simply failed from long, sustained periods of use in adverse environmental conditions (e.g., high heat and humidity).

Though we only used 2 different CD player models in our field tests, our experiences suggest that our method can be utilized in most portable CD player models, eliminating the need to design a unique PBDM in each case. For instance, we employed our soldering method on a third model (Memorex MD8151SL; Imation Corporation, Oakdale, MN) that utilizes a 4-pole momentary action pushbutton switch and on a fourth model (SONY D-EJ011; SONY Electronics, Inc., San Diego, CA) that utilizes a right-angle tactile switch. In each case, our method was successful at initiating playback, yet both of these latter models incorporated electronic volume buttons that are connected to the same integrated circuit board as the play button, rendering volume control unusable when the play button is activated (either by manual compression or electrical connection). We, therefore, chose to use the INSIGNIA models, which had a volume control dial not reliant on the integrated circuit board associated with the play button, and other experimenters should take this into consideration when designing their own systems.

Manipulating animal populations using broadcast systems for both experimental and management purposes holds great promise (Nocera et al. 2006, Betts et al. 2008, Ahlering et al. 2010, Farrell et al. 2012), yet can also be expensive, time-consuming, and logistically challenging to implement. Drawing correct and useful conclusions from manipulative experiments or management procedures that involve sound broadcast is contingent on broadcast treatments being applied correctly, often in the absence of a human observer.

In such instances when a broadcast system fails, there is no way to determine when the failure occurred, making it impossible to quantify the number of broadcast hours for that treatment period and thereby adding another source of variability to the experiment. In the systems we used, for instance, failure of any component could result in between 0 hours and 56 hours of lost playback time, depending on when during the treatment period the component failed. As such, any improvement in system reliability will, in turn, improve our ability to generate and accurately interpret results, and reduce the number of man hours required to maintain such experiments. We suggest that our method of soldering the CD player play button is a reliable complement to broadcast systems used in ecological research and for management practices that involve using sound broadcast.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article at the publisher's web-site.

Step-by-step instructions for soldering the electrical connection of a CD player play button that utilizes a tactile momentary action pushbutton switch.