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SONGBIRD DISTRESS CALLS AS AN IMPROVED METHOD FOR DETECTING RED-SHOULDERED HAWKS (*Buteo lineatus*)

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Abstract.—We present an audio playback method that increases the probability of encountering, and consequently increases the efficiency of detecting, counting, and monitoring, Red-shouldered Hawks (*Buteo lineatus*). Our design involves a passive census period prior to and following a playback period with broadcast of one of two, five-minute pre-recorded playbacks: distress calls of Tufted Titmouse (*Baeolophus bicolor*), or perched calls of Eastern Screech-Owl (*Megascops asio*). We conducted fixed-radius point counts before, during, and after playback periods at 124 independent sites in north-central Florida from September 2012 to May 2013. We used generalized linear modeling to estimate the effects of habitat type, census period, and treatment (playback type) on the probability of the presence of Red-shouldered Hawks on surveys. We detected raptors (*B. lineatus*) on 10 (8%) surveys prior to playback of either treatment (distress, owl). Following playback of *M. asio* we detected raptors (Red-tailed Hawk, *B. jamaicensis*; Barred Owl, *Strix varia*) on two surveys (0.3%). Following playback of *B. bicolor* we detected raptors (Red-tailed hawk, Red-shouldered Hawk, Barred owl) on 21 surveys (34%). A post-hoc multiple comparisons test of the fixed interaction effect among treatment and playback periods detected a significant effect of distress call playback on the probability of presence of Red-shouldered Hawk both within, and across treatments. We conclude that songbird distress calls significantly enhance the detectability of Red-shouldered Hawk within the sound-exposed area, and thereby decreases the effort required to census for these, and possibly other, raptorial species.

Introduction

Accurate and precise estimates of density, abundance and occupancy of animals directly influences the capacity to monitor, assess and predict population trends. Population estimates are especially challenging when attempting to census species that are non-colonial, highly social, trap-shy or cryptic (Fuller and Mosher 1981, Johnson et al. 1981, Legare et al. 1999, Johnson et al. 2014). The majority of bird species, because they rely heavily on vocal and visual communication cues that humans can readily detect, represent favorable subjects for detection and monitoring programs, assuming that observers are skilled in sound and sight identification. Common techniques for censusing terrestrial birds include point counts and transects using human observers on foot or in vehicles (Fuller and Mosher 1981, Bibby et al. 1992) and, increasingly, automated acoustic monitoring (Gregory et al. 2004, Acevedo and Villanueva-Rivera 2006, Blumstein and Mennill 2011). Point counts and acoustic monitoring applied to avian communities and individuals can be relatively efficient because of the predictability of their diurnal activity and vocalization periods (Palmgren 1949). Such methods can be standardized to rely on the assumption of uniform detection among survey samples or can be conducted in ways that allow for the estimation of detectability (Buckland et al. 1993).

***Raptor survey methods*.—**Many raptor species, however, present a variety of unfavorable characteristics for detection and population estimation with standard avian survey techniques. Raptors exhibit highly cryptic behaviors and their coloration typically maximizes background matching which, by design, decreases the probability of detection by humans and prey (Fuller and Mosher 1981, Newton 1986, Andersen 2007, Henneman et al. 2007). Consequently, passive point and transect surveys yield low numbers of raptor detections, usually with very low detection probabilities (Millsap and LeFranc 1988). This limits accuracy and precision in relative abundance, occupancy or density estimation (Sattler and Bart 1984) and can only be overcome with very large (extensive) sample sizes or repeated (intensive) sampling. One common, extensive technique applied to assess relative abundance of temperate, diurnal raptors is the roadside survey (Andersen et al. 1985, Millsap and LeFranc 1988, Ellis et al. 1990). Roadside surveys rely on the probability of detecting raptors that are soaring or vocalizing during the census period and are conducted over long distances of vehicle-accessible trails or roads. Because soaring and vocalizing are relatively infrequent in the diurnal cycles of most raptors, underestimation of raptors in roadside surveys is assumed. Moreover, because of the large distances between sampling points, roadside surveys provide data that are course-grained and relatively inaccurate with respect to habitat associations for most raptor species (Burnham et al. 1980, Fuller and Mosher 1987).

***Use of playbacks in avian censusing*.—**Many small to medium-sized raptors occupy home ranges that are scale-appropriate for point- or transect-based census methods. Therefore, a focus for improving census methods for raptors should focus on enhancing the probabilities of detection, despite their cryptic phenotypes. The use of taped call playbacks (hereafter, playbacks) to enhance detection has become more frequent in surveys for many cryptic bird species, including raptors (Johnson et al. 1981, Marion et al. 1981; Harris and Haskell 2013). Two classes of playback stimuli are typically used with birds to elicit different kinds of conspicuous behaviors; (i) conspecific (i.e. territorial) vocalizations (Stamps 1988) and (ii) predation-related vocalizations, including calls of predators and/or their prey (scolding, mobbing, or distress calls). Conspecific vocalizations can be used for single species to elicit territorial defense and display behaviors such as close approaches, counter-singing, wing flicking, and frequent perch changes (e.g., Mosher and Fuller 1990, Andersen 2007). Predator scolding (mobbing) calls, or calls of predators themselves, have been used primarily with non-raptorial birds to attract multiple species at once. Scolding calls of birds that are preyed upon by raptors as well as raptor (and other predator) vocalizations will generate multi-species 'mobs' of prey birds exhibiting conspicuous predator inspection behaviors such as close approaches, frequent perch changes, and alarm vocalizations (Falls 1981, Hurd 1996, Forsman and Mönkkönen 2001, Johnson et al. 2004, Sieving et al. 2004, Langham et al. 2006, Magrath et al. 2007). This method has been used to census non-breeding passerine bird communities (Turcotte and Desrochers 2002), but has not been applied to raptors.

Conspecific playback can be used to map territories of focal individuals or groups (Kendeigh 1944; Bibby et al. 1992), and short-duration playbacks of territorial calls have been used to evoke conspicuous behaviors (i.e. eliciting sentinel behavior on high perches) during censusing. For example, broadcasting vocalizations following a period of passive census for Florida Scrub-Jay *Aphelocoma coerulescens* greatly enhances this species' detectability (Johnson et al. 2014). Conspecific territorial playbacks are used in raptor surveys (e.g., Mosher et al. 1990, Watson et al. 1999, Salvati et al. 2000) and in raptor capture attempts (Bloom et al. 2007; Rosenfield et al. 2007). As with most species, (conspecific) playback often functions only during early-breeding-season sampling and is difficult to apply when more than one species is being counted. This is because large raptors prey on smaller species of raptors and songbirds alike; playback of multiple species of raptor calls from one location may suppress responses of the more vulnerable species (Call 1978).

Study objectives.—We present data supporting a playback technique that can attract raptorial species outside of the breeding season, and that will increase the efficiency of detection of Red-shouldered Hawks *Buteo lineatus* relative to passive surveying techniques. Like other birds, raptors spend the majority of their time seeking food (e.g., Plumpton and Andersen 1997). We have noted that hawks and jays are sometimes attracted to the distress calls of small passerines during handling at mist nets. Therefore, we investigated the utility of songbird distress calls to invoke prey inspection behavior by raptors. Distress calls are elicited under a variety of conditions when individuals perceive imminent harm or experience contact with an attacker (Norris and Stamm 1965). Among the functions of distress calls proposed in the literature, the three most common are that (1) captured prey use them to directly startle their captor into letting go (startle-predator hypothesis; Driver and Humphries 1969), (2) that distress calls can attract aggressive mobs of family members or heterospecifics to drive the captor away (call-for-help hypothesis; Rohwer, et al. 1976), or (3) that by signaling vulnerability, the distressed prey can attract a counter-attack by a competing predator that could distract the captor into releasing the captive (predator-attraction hypothesis; Curio 1976). Some evidence supports the first two hypotheses. Distress calls can elicit approach and inspection responses by heterospecifics and conspecifics (Stefanski and Falls 1972, Perrone 1980, Hill 1986, Aubin 1991). Regarding (3), recreational and sport hunters have long recognized that prey distress calls can readily attract predators (Branch and Freeberg 2012). For example a bestselling predator caller device broadcasts (among others) the distress calls of jack- and cottontail rabbits and snowshoe hares, deer fawns, voles, squirrels, prairie dogs, and three bird species (FOXPRO® Spitfire Predator Caller). Under the assumption that raptors are highly motivated to approach and inspect a distressed and presumably incapacitated prey, we tested whether the use of songbird distress calls could enhance the rate of detection of woodland raptors in North-central Florida.

Methods

Study area.—Research was conducted in hardwood forests of north Florida at Ordway-Swisher Biological Station (OSBS) near Melrose (Putnam County; N 29° 41' 22.8588", E -82° 0' 10.1304"), Gold Head Branch State Park (GHBSP, Clay County, N 29° 50.041', E -81° 56.747") and additional samples were taken at various city, private and state-managed natural lands in Gainesville (Alachua County). Sample locations occurred in mesic to xeric woodlands with > 40% canopy cover of mixed hardwood and pine. All study species occur throughout the heterogeneous woodland ecosystems of north-central Florida, therefore the only requirement was that the habitat be natural woodland.

Playback recordings.—We used two types of playback recordings for this study; the distress call of the Tufted Titmouse (*Baeolophus bicolor*), and recordings of an Eastern Screech-Owl (*Megascops asio*). The Tufted Titmouse is a common songbird of eastern North American woodlands and is a common prey item in the diets of a variety of raptor species (Courter and Ritchison 2010). We used species lists maintained by park officials (e.g., Gold Head Branch State Park 2004. OSBS 2004) to compile a list of predator species expected at our study sites. When species lists were unavailable we referred to eBird (2012; Table 1). In north-central Florida, unpublished observations of raptor attacks on titmice suggests that the most common avian predators of titmice are accipiters (e.g.,

Table 1. List of raptors potentially detectable in our study area and the number of detections they were observed in each survey or set of survey periods. We conducted a total of 373 point-count surveys for this study at 124 sites, and observed raptors during a total of 23 surveys. Species in bold were detected during this study, others were not detected during this study.

Red-tailed Hawk, *Buteo jamaicensis*
Barred Owl, *Strix varia*
Red-shouldered Hawk, *B. lineatus*
Broad-winged Hawk, *B. platypterus*
Northern Harrier, *Circus cyaneus*
Merlin, *Falco columbarius*
American Kestrel, *F. sparverius*
Barn Owl, *Tyto alba*
Great Horned Owl, *Bubo virginianus**
Eastern-Screech-Owl *Megascops asio**
Cooper's Hawk *Accipiter cooperii**

*Species detected during informal playback of Tufted Titmouse distress call playback but not detected during this study's sampling efforts.

Sharp-shinned Hawk [*Accipiter striatus*], Cooper's Hawk [*A. cooperii*]; K. E. Sieving, unpublished data). Some owls and hawks are highly opportunistic predators that should also be attracted to inspect a distressed titmouse.

***Census protocol.*—**We counted individuals within a 25 m fixed radius about a single point at which a playback device was centered. We assumed the detection rate of any individuals within this radius would be high (Buckland et al. 1993; Pacifici et al. 2008). To test the effects of playback type on avian predator response (i.e., a predator approaching the playback device), we broadcast one of two playbacks: (1) the recorded distress call of a tufted titmouse from wild, captured birds in the hand (recorded by T. Freeberg), or (2) the perched call (trill) of an Eastern Screech-Owl (files obtained from Xeno-Canto online database). Titmice are vocal during handling and emit distress calls; high pitched vocalizations that are not produced in any other context while the birds are free-living. For each trial within each treatment, we randomly chose a playback file from ten distress-call and three screech-owl five-minute, looped playback files (.wav format). We conducted 372 censuses across treatments at 124 sites between September 2012 and May 2013. We restricted playbacks and surveys to between 30 min after sunrise and 1100 EST to avoid inactive hours of the day.

At the beginning of each sampling day we walked or drove along a trail or road until we were at least 300 m from any previously sampled point (using distance estimation tool on GPS unit; < 10 m accuracy); we then walked off the trail or road for approximately 25 m and obtained the location of this point using the GPS. We chose a minimum of 300 m distance as an effective distance at which songbirds may not be conditioned by our playback treatments. We suggest that future protocols include a minimum sampling distance of at least one home range of the target, raptorial species, to reduce both the probability of sampling the same species, or of conditioning individuals. We played back sounds on an iPod connected by wired to a battery-powered speaker (Radio Shack model 277-1008) mounted on a 3 m pole, and before each count we placed the pole at a slight angle against a tree, allowing the speaker to sit between 2.5 m and 3 m above the ground. We then retreated with iPod in a random direction to a location approximately 10 m from the speaker. Following a period of silence we conducted a 3-min fixed-radius point-count, recording all raptors seen and/or heard within a 25 m radius. We then immediately applied the treatment for 3 minutes, during which time we simultaneously broadcast a playback and conducted the second 3-min census. Following this playback period, we ceased playback and immediately conducted the final 3-min census. All censuses conducted followed the methods for fixed-radius point counts described by Hutto et al. (1986). We also took note of raptors seen or heard beyond. This sampling scheme resulted in three sampling periods (Pre-, During-, and Post-playback). All observations and playbacks were conducted by J. Burnett. During pilot studies we conducted five- and ten-minute playback periods, and observed raptors responding to the playback within the first two minutes; therefore, we decided to use a shortened sampling period (of three minutes) during this study.

We standardized the volume of playback emitted by the speaker to ensure similar sound degradation (and sampling area) across sampling points. The average minimum, maximum, and mean volumes of the ten titmouse recordings used were 45.4 dB, 98.3 dB, and 65.2 dB, respectively. These measurements were obtained at a distance of 1 m from the playback speaker using the Decibel 10th application (Apple iPhone 6). The specific note types comprising titmouse distress calls (related to Z and D notes, Owens and Freeberg 2007) originating from the speakers at these sound levels degrade to near zero signal-to-noise ratio by approximately 50 m to 60 m from the sound source in dense forest (J. R. Lucas, unpublished data). Therefore we expect our sampling area to be within a circle with radius < 70 m around the sound source, although we do not know if predator sensory detection and motivation to approach the speaker are directly correlated with spectral degradation of the signal. It is, however, very likely that this method would only attract individuals whose home ranges included the broadcast area, and is assumed we did not pull birds from adjacent territories in to the detection circle (Gunn et al. 2000).

Statistical analyses.—We conducted all analyses in Program R version 3.1.2 (R Core Team 2014). We converted predator detections (abundances) for each census to binary presence/absence data (0=absent, 1=present). We fit the data with a generalized linear model (package *stats*) using a logit transformation and binomial error structure, and evaluated model fit using likelihood-ratio chi-square test. We included two fixed effects in our model: all levels of interaction of treatment and playback period (N_{levels} = 6), and the effect of habitat type (cateogorical, N_{levels} = 3). We tested the hypothesis of no difference among the interacting groups using a post-hoc multiple comparisons using the generalized linear hypothesis test (packages *glht*). Means and standard errors about the estimated probabilities are presented on the logit scale.

Results

We observed raptors at a total of 23 of 124 sites overall, with most observations occurring after initial playback of the Tufted Titmouse distress call. Raptors responding to the distress call playback were primarily Red-shouldered Hawks, and included occasional Red-tailed Hawks and Barred Owls. On all but one occasion raptors approached singly; on one occasion, two Barred Owls approached the speaker together. The model including habitat type as a fixed effect was not an adequate fit of the data (D_5 = 25.77, P <0.001), but the nested model disregarding habitat type and including only the interaction effect (i.e., the less complex model) was an adequate fit (D_2 = 2.23, P >0.10). Multiple comparisons indicate significant effects of both the treatment applied (distress call versus owl playbacks) and between sampling periods of distress call treatments (Fig. 1).

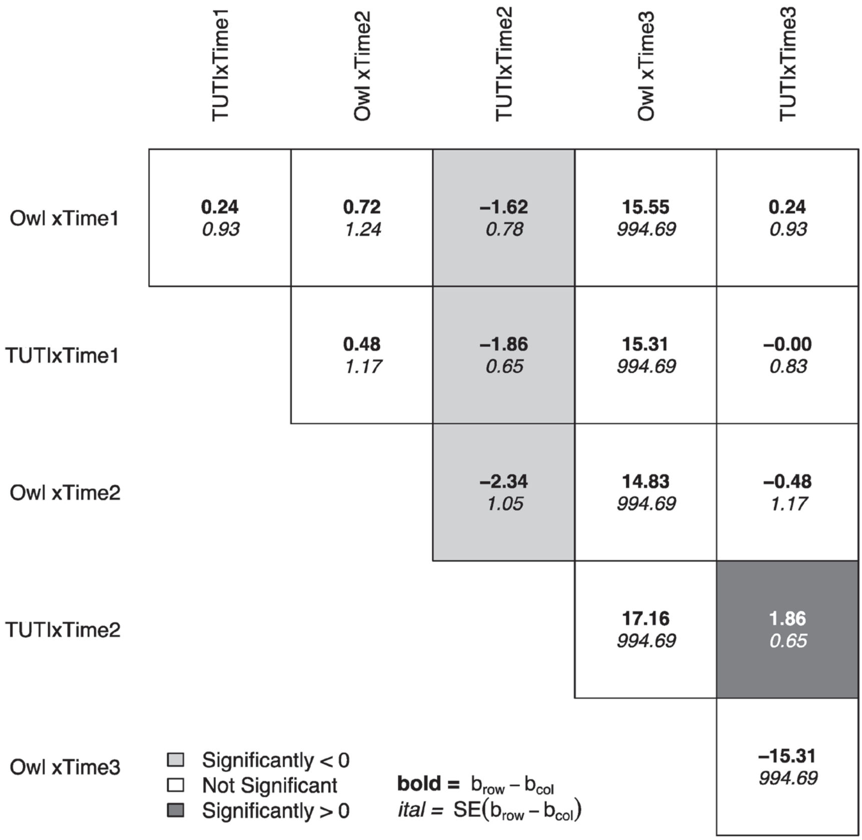

Figure 1. Factor plot of all pairwise interactions examined on the response of Red-shouldered Hawks to two playback treatments, Eastern Screech-Owl ("OWL") and Tufted Titmouse ("TUTI"), across three sampling periods, before playback ("Time1"), during playback ("Time2"), and after playback ("Time3"). Estimated probability of response by predators (b) are given on the log-odds scale. A value significantly different from zero (i.e., mean +/- SE does not include zero) indicates a statistically significant influence in the probability of a raptor responding to the playback.

Discussion

The distress calls of the Tufted Titmouse significantly enhanced the probability of detecting raptorial species in forested habitat of north-central Florida. With a relatively small sample size, we detected a large effect of playback of a "screaming" Tufted Titmouse on the probability of detection (of Red-shouldered Hawks). Due to the time and resource-intensive nature of surveys for birds of prey (Fuller and Mosher 1987, Andersen 2007), such a large positive change in an observer's probability of detection will improve the practicality of including raptor species in sampling regimes that are intensive; that is, point-based census methods applied in high densities within habitats that detect individual and population distributions at relatively fine scales. Just as species-specific calls are used to better detect many cryptic birds that exhibit low calling rates (e.g., rails and Florida Scrub-Jay), our method enhanced the detectability of present but hidden individuals. And like mobbing-call playbacks, which can elicit approaches by numerous different species simultaneously (e.g., Langham et al. 2006), our distress-call playbacks attracted several species of predators.

We intentionally used a brief 3-min period to keep the overall sampling period under 10 minutes (akin to typical point-count periods). Longer playbacks could conceivably lead to double counting if birds approached, were flushed, and then returned again. In a pilot study, we used longer playback periods of up to 30 min and accipiters that were attracted to the calls would often swoop repeatedly past the speaker to investigate (Sieving and Burnett, unpublished data). We detected raptors in both non-breeding and breeding seasons using this method during morning sampling periods. Indeed this method should be effective in all seasons and situations with hunting raptors. During our pilot work we also sampled during crepuscular and evening periods and obtained high response rates by Barred Owls (> 50% detection rate during playback of distress calls). On one informal sampling occasion we observed simultaneous investigation of the speaker by one Great Horned Owl, one Barred Owl, and two Eastern Screech-Owls on a forest edge after dusk. Like Branch and Freeberg (2012) we detected various songbirds (including titmice) that responded with varying intensities of apparent predator inspection behavior (e.g., mobbing behaviors as observed to owl call playback; Sieving et al. 2004). Hence, there may be other applications of the distress call playback in behavior-based sampling of non-raptorial birds. However, only Red-shouldered Hawks were statistically more likely to be present during the playback period than were other responding raptors. The distress-call playback method presented here has several attributes that enhance its utility over that of typical playback applications: (1) it is useful in all seasons as a playback type that should elicit response by hunting predators within earshot; (2) it can be used in diurnal, crepuscular and early evening hours; and (3) it can enhance detection of more than one species simultaneously (Burnett and Sieving, unpublished data).

All playback methods, because they elicit approaches by target birds, lead to violation of a key assumption underlying census-based population estimation; that of unaltered distribution of target individuals (Buckland et al. 1993). In eliciting approaches, playback will cause an over-estimation of density by reducing detection distances

(Johnson et al. 2014). Playback may not be as problematic in occupancy modeling if the sampling area within which raptors respond can be estimated and incorporated into the analysis. If, however, the goal of the survey is to estimate relative abundances only or to detect presence or absence of a species within patches or stands of habitat at the scales of smaller raptor home ranges, then this method should be of great value.

Prior to incorporating this method into raptor surveys, a variety of considerations may be useful. We recommend that observers (1) use the playback only after one or more periods of passive censusing to estimate changes in detection rates with playback (MacKenzie et al. 2003, Riddle et al. 2009), (2) playback volumes should be calibrated within sampling habitats to ensure that the area exposed to playback experiences similar degradation (Ratcliffe et al. 1998; Sieving, et al. 2004), (3) preliminary behavioral studies of target species could help understand if and how they respond to species-specific distress calls being considered, and (4) given the probability that multiple responding predators could interfere with detection of target species, this should be accounted for in the sampling strategy (Sergio and Hiraldo 2008). Overall, this study suggests the use of the distress call of a small songbird may provide a supplementary method of enhancing an observer's probability of detecting and, therefore, counting, raptorial species in forested areas.

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