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Assessment of foraging activity using Anabat II: A cautionary note

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Recent availability of low-cost and easy-to-use bat detectors, such as Anabat II (Titley Electronics, Ballina, Australia). has made assessment of bat activity accessible to an increasing number of researchers and land managers. Researchers using bat detectors have attempted to identify species assemblages (e.g., Fenton et al., 1983; O'Farrell et al., in press) or compared bat activity between areas or among habitats (e.g., de Jong and Ahlen, 1991; Hayes and Adam. 1996; Walsh and Harris, 1996b). Researchers also have used bat detectors to compare relative amounts of foraging activity between areas (Brigham et al., 1997; Crampton and Barclay, 1996; Erickson and West, 1996; Krusic et al., 1996; Thomas, 1988; Vaughan et al., 1997; Walsh and Harris.1996a).

Earlier investigators separated echolocation calls of bats into three phases: search, approach, and feeding buzz (e.g., Fenton and Bell, 1979; Griffin, 1958; Simmons et al., 1979). These three categories are still used and can be visualized in the field when bat detectors are connected to oscilloscopes (e.g.; Fenton and Bell, 1979) **or** laptop computes (e.g., O'Farrell et al., in press). Most researchers that attempt to assess feeding activity in the field using the audio output of bat detectors, describe their methods as "foraging activity was recognized by high pulse repetition rates, or feeding buzzes, associated with attacks on prey" (Griffin, 1958). However, no recent studies have been published that test the validity of this methodology, using modem equipment, such as the Anabat Il. It had been stated that the feeding activity can be unambiguously assigned from the audio output of the QMC mini-detector (Fenton et al., 1983). These statements imply that the sound of a feeding buzz is equally apparent to all researchers, and that this sound is actually produced by a bat in the act of feeding to test the former. We conducted a survey in which we asked bat researchers to categorize prerecorded bat calls.

Our goal was to evaluate the variability among observers in categorizing bat calls using the audio output of bat detectors Our null hypothesis was that categorization of bat calls is an objective task repeatable by other researchers. If classification of bat calls is objective, calls should be classified similarly by different observers, and experience of the observer should not significantly affect how calls arc classified. If categorization of calls is objective, but difficult to learn, there should be greater variability among inexperienced observers on how calls are categorized compared to experienced researchers.

Materials and Methods

We recorded calls of *Myotis* spp. in the Pilot Creek watershed in Six Rivers National Forest, ca.50 km east of Eureka, California. Calls were identified as *Myotis* spp. by viewing the time-frequency structure of the calls using the Anabat II Zero-Crossings Analysis Interface Module. Anabat 5 software, and a laptop computer (e.g,. O'Farrell et al., in press).

Rccordings were made along stream channels within mature Douglas-fir (*Pseudotsuga menziesii*) forest bctween June and August 1996. We used the Anabat II but detector, in conjunction with the Anabat II delay switch and a Realistic minisette-20 tape recorder to record remotely calls in the field (Hayes and Hounihan, 1994). These materials were similar to those used in previous studies that passively monitored bat activity (e.g.. Hayes, 1997; Krusic et al., 1996; Parker et al., 1996).

Ten calls were subjectively selected for inclusion on an audio tape to assess variability among observers in identification of calI type. The first two calls were intended to orient the listener to the quiz process while listening to calls that were easy to categorize. The first was one that we agreed had no feeding component, i.e., a search-phase cal1. The second was a call that we agreed was an obvious feeding buzz. Calls 3-10 were ambiguous calls that we disagree among ourselves as to whether they were approaches or feeding buzzes The quiz tape was not meant to approximate 10 call that one would acquire during a night of field recording

Respondents were surveyed at the North American Symposium on Bat Research in Tucson, Arizona, between 9 and 11 October 1997. First theywere asked to report their years of experience with bat detectors, the Anabat system, and whether they regularly distinguished among call types. Next they listened to the tape of 10 calls through headphones and attempted to categorize each call as search approach, or feeding buzz

Many respondents placed calls into more than one category. Since we were most interested in whether respondents detected a feeding buzz., we used only the respondents' highest level of categorization in our analyses.For example. if the call were categorized as having both a search phase and an approach phase, we used an approach in the analysis. Respondents were segregated into two groups: experienced (≥ 3 years of bat detector experience) and less experienced (≤ 3 years experience). We pooled the identifications and used chi-squared contingency table analysis to test for association between experience level and how calls were classified.

Results

Twenty-six researchers responded to the survey, resulting in 252 identifications of the 10 calls (eight calls were not identified). Mean experience with bat detectors was 4.5 years (range: 1 month to 21 vears), and mean experience with Anabat detectors was 1.3 years (range: 1 month to 4 years). Eighty-four percent of respondents reported that they regularly distinguished between search and feeding calls, and 31% regularly distinguished between approaches and feeding.

Categorization of bat calls was highly variable. Hereafter, our results refer to a respondent's highest level of categorization for a particular call. None of the calls was identified the same by all 26 observers. Six of 10 calls were identified the same bv $\geq 50\%$ of the respondents, and only one (call 2: the obvious buzz) was placed in the same category by $>68\%$ of the respondents (Fig. 1). All ten calls were identified as either an approach or feeding buzz by a majority ($\geq 58\%$) of the respondents. However, only three calls (2, 3, and 5) were identified as either an approach or feeding buzz by $\geq 95\%$ of the respondents.

Of the 252 identified calls, 14.7% were identified as a search, 36.1% as approach, and 49.2% as feeding buzz. There was no significant association between observer experience and identification of call type (X^2 = 4.21, $P = 0.12$, $d.f.$ = 2) or assignment of the feeding buzz call type ($X^2 = 0.01, P = 0.92, d.f. = 1$; Fig. 2).

Discussion

Our null hvpothesis was rejected, and we concluded that categorization of bat calls based on recorded audio output of Anabat detectors is subjective. There was great variability in classification of the 10 calls, and there was no association between the observer's experience with bat detectors and how calls were classified. If calls could be reliably identified from recorded audio output of bat detectors, then one type of call would dominate for each of the ten calls in Fig 1. The variability among observers in identification of call types is cause for concern to those who attempt to infer foraging activity from the audio output of divid-by-n bat detectors, such as Anabat II.

We expected a great deal of variation in identification of calls as either approach-phase calls or feeding buzzes, because these types of calls can be difficult to distinguish even when analyzing time-frequency graphical displays Kalko, 1995; Parsons et al., 1997). The number of respondents who identified calls as searches was unexpected. Since the calls on the quiz tape were primarily chosen for their ambiguity, all calls may not be this difficult to categorize. However, we included two calls that we assumed would be easy to categorize. The original intent of these two calls was to demonstrate that most researchers would agree on obvious call types. Call two met thcsc expectations, but call one, which we considered to be a typical search call, was identified as an approach (42.6%) and even a feeding buzz (11.5%) instead of a search (42.3%). This demonstrates the subjectivity inherent in audio determination of calls. Given that calls of ambiguous type exist, in practice they are probably subjectively assigned to a category. It is likely that a test asking researchers to categorize randomly selected calls would display variability similar to that presented here.

Our survey was conducted using recordings of *Myotis* spp. made with the Anabat II system in forested habitat. Our results and conclusions arc limited to these species, in this habitat, using this recording system. Experience levels were reported as years of bat-detector use. We realize that use rates within a year vary appreciably among respondents. Also, the survey was conducted in the lobby outside a scientific meeting that presents different conditions than the relative quiet of the laboratory. Nevertheless, despite several uncontrolled parameters in this study, the observed trends are not encouraging.

A majority of researchers surveyed attempt to identify foraging activity, defined by most researchers as occurrence of "feeding buzzes" (e.g., Krusic et al., 1996; Thomas, 1988) in the field. Our data indicate that categorization of feeding buzzes based solely on recorded audio output of Anabat II detectors may be subjective and not repeatable. Only call 2, which we identified a priori as a feeding buzz, achieved $\geq 95\%$

concurrence on its categorization. Frequent calibration in identifying feeding buzzes among researchers on a particular study may alIow for relative comparisons of foraging activity among habitats. However, this method may not accurately estimate the actual amount of foraging in an area. To complicate matters further, some insectivorous bats may not use echolocation to capture prey (Fenton, 1990).

Alternatively, foraging activity could be defined as the presence of either approaches of feeding buzzes. Since approach-phase calls occur when the bat is pursuing prey (Kalko, 1995). the detection of an approach-phase call would indicate foraging activity. However, during our survey, in only three of 10 cases did researchers achieve **≥95%** agreement that the call was either an approach or feeding buzz.

Calls have been successfully assigned to one or more of these phases by qualitatively assessing changes in call design, using time-frequency displays of the echolocations on oscilloscopes, and while observing behaviors of the bats (e.g., Fenton and Bell, 1979; Fenton et al., 1983; Kalko, 1995). Call type has been quantitatively assessed for *Chalinolobus tuberculatus* but required the use of digital, signal-processing equipment and multivariate anal ysis to separate calls into search and terminal-buzzes (Parson et al., 1997). Despite the technology and effort expended, approach calls could be recognized but not quantitatively distinguished from feeding buzzes (Parson et al., 1997). Most respondents to our survey did not attempt to distinguish approach calls in the field but did attempt to identify feeding buzzes. Passive monitoring of activity with bat detectors and later listening to the audio output does not allow consistent determination of call type. While it has been suggested that the human brain may be the most effective tool for analyzing sounds (Fenton, 1988), our data indicate that the audio determinations of call type are subjective, even at a level that separates approaches and feeding buzzes from searches.

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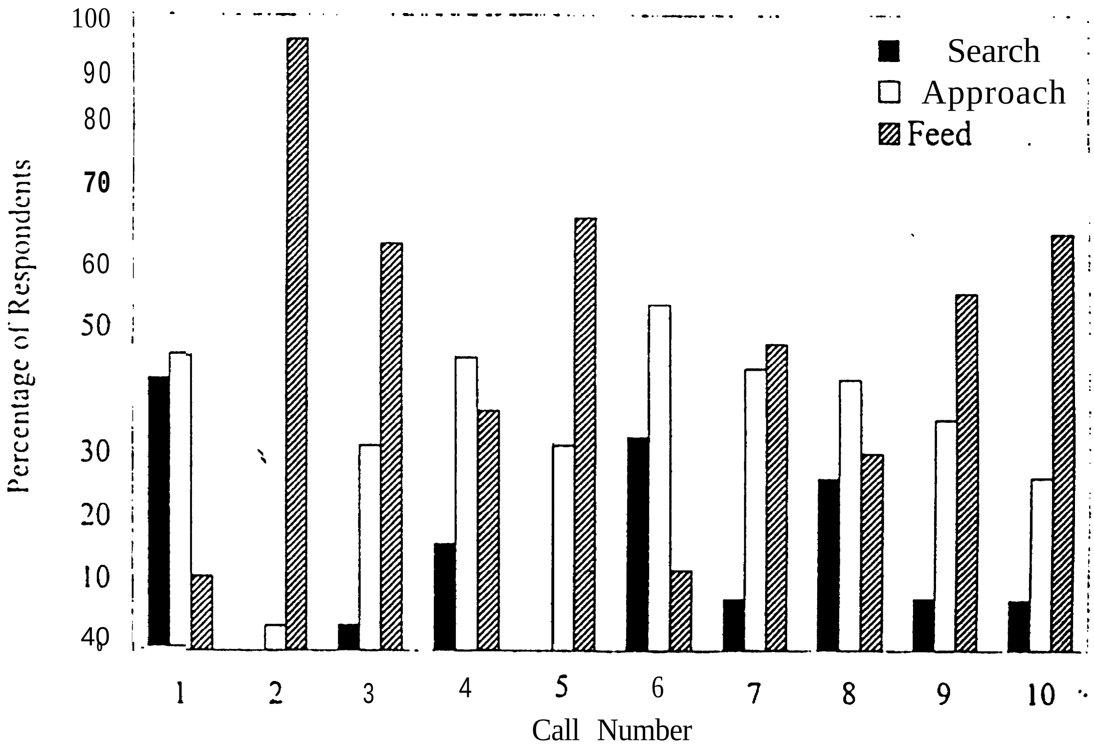

Figure 1. Identification of bat call types by researchers. 36 respondents listened to the same 10 calls.