Comparison of Anuran Call Survey Durations in Tennessee Wetlands

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Abstract: Anuran breeding call surveys are widely used to document species richness and relative abundance. Call survey protocols used by the North American Amphibian Monitoring Program are five minutes in duration. However, recent studies have suggested that 5-minute call surveys may not be long enough to accurately estimate species richness or relative abundance. Therefore, we tested whether anuran species richness and relative abundance differed between 5- and 10-minute breeding call surveys. We conducted 344 call surveys from March–August 2005 and 2006 at eight wetlands on the Cumberland Plateau in Tennessee. On average, 95% of species recorded in 10 minutes were heard within the first five minutes. Mean species richness did not differ ($P = 0.17$) between 5- and 10-minute surveys. For species we detected, mean relative abundance was not different ($P > 0.07$) between 5- and 10-minute surveys. However, mean species richness and relative abundance of northern cricket frog (Acris crepitans) and American toad (Bufo americanus) was different ($P < 0.03$) between two observers. Our results suggest that 5-minute breeding call surveys are adequate to document common anurans in Tennessee wetlands. Also, coordinators should consider assigning only one individual per monitoring route because of the possibility of multiple-observer bias.

Key words: amphibians, anurans, call surveys, frogs, monitoring, multiple-observer bias, Tennessee, wetlands

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Amphibian populations are declining globally (Stuart et al. 2004). Since 1989, over 125 amphibian species have exhibited significant declines and several are presumed extinct (Keisecker et al. 2004). In Tennessee, 26 amphibian species are listed as species of state or federal concern (Tennessee Wildlife Resources Agency 2005). The most common technique for monitoring anuran (frog and toad) populations is breeding call surveys. Because volunteers usually perform call surveys, they are an economical approach for regional detection of fluctuations in anuran populations (Shirose et al. 1997).

The North American Amphibian Monitoring Program (NAAMP) was established in 1994 to begin collection of standardized amphibian population distribution and abundance data in the United States and Canada (Weir 2001). Although approximately two-thirds of the United States has anuran monitoring programs (e.g., Tennessee Amphibian Monitoring Program), some states do not follow NAAMP protocol. The primary difference among state programs is duration of breeding call surveys, which range from 3–10 minutes. The standard for NAAMP surveys is to listen for anurans at a fixed location for five minutes (Weir 2001). Shirose et al. (1997) provided evidence that 5-minute call surveys were sufficient to detect most anurans in Ontario, Canada, wetlands. However, Crouch and Paton (2002) and Pierce and Gutzwiller (2004) reported that 10- and 15-minute call surveys were necessary to detect >90% of the amphibian species in Rhode Island and Texas, respectively. Variation in these results suggests that detection efficacy may vary regionally (Pierce and Gutzwiller 2004). No studies have evaluated influence of survey duration on the number of anuran species detected in the southeastern United States. Additionally, protocol for NAAMP requires ordinal ranking of species abundance (Weir 2001). However, few studies in North America have evaluated influence of survey duration on species-abundance ranking (Bridges and Dorcas 2000, Crouch and Paton 2002). Lastly, multiple-observer bias has been reported in point-count surveys for birds (Thompson 2002), but its occurrence has been infrequently investigated in anuran call surveys (Genet and Sargent 2003).

Our objectives were to determine if differences existed in mean species richness and relative abundance 1.) between 5- and 10-minute surveys and 2.) between two observers with similar amphibian call survey training. This information will be useful in determining whether the 5-minute NAAMP standard is effective for monitoring amphibian populations in Tennessee, and whether using multiple observers per route may bias species richness and relative abundance estimates.

Methods

We conducted our study on the Cumberland Plateau at the University of Tennessee Plateau Research and Education Center near Crossville, Tennessee (36°00´59″ N, 85°07´57″ W, 550 m elevation). We performed 43 breeding call surveys (one per week) from 28 March–22 August 2005 and 27 March–21 August 2006 at eight emergent wetlands (0.14–1.04 ha) resulting in 344 independent surveys. The wetlands used in our study had emergent non-persistent and persistent herbaceous vegetation along the shoreline and permanently flooded, unconsolidated bottom in the center (Cowardin et al. 1979; Burton 2007). Species composition was mostly cattail (*Typha latifolia*), rushes (Juncaceae), and sedges (Cyperaceae).

Our survey methods followed NAAMP protocol (Weir 2001) except that data were collected for two survey durations (0-5 and 0-10 minutes) and with two observers. Observers stood at permanent listening stations on opposite sides of each wetland and did not share survey results. We began surveys ≥30 minutes after the U.S. Naval Observatory published time for sunset (http://aa.usno.navy.mil/data/docs/RS_OneYear.html). Upon arriving at listening stations, we waited for one minute before beginning surveys to allow observers to acclimate to surroundings and for anurans to recover from possible disturbances. All species heard were recorded separately for 5- and 10-minute surveys, and species-specific abundance indexed. Following NAAMP protocol, an abundance index of 1 was given when individual calls of a species were distinguished but did not overlap, an index of 2 was assigned when calls overlapped but individuals could be distinguished, and an index of 3 was assigned when there was a full chorus (i.e., calls overlapped and individuals were indistinguishable, Weir 2001).

Using these data, we calculated proportion of surveys that anuran species richness and relative abundance was greater in 10-minute than in 5-minute surveys. Next, we averaged species richness and abundance estimates per survey between observers and tested if mean species richness and abundance was different between 5- and 10-minute surveys using a one-way analysis-of-variance (ANOVA, Milton and Arnold 1995). We also estimated a species accumulation curve to graphically illustrate proportion of species detected on average from 0–10 minutes (Shiu and Lee 2003, Pierce and Gutzwiller 2004). Mean species richness and abundance also were tested between observers using a one-way ANOVA (Milton and Arnold 1995). We averaged species richness and abundance between 5- and 10-minute surveys before conducting observer analyses. All tests were performed at $\alpha = 0.05$ using the SAS system (Littell et al. 1991).

Results

We performed 344 call surveys in two years but only used 321 for species richness analyses because no anurans were heard during 23 surveys. Sample size for species-specific abundance ranged from 20 to 244 and was equal to number of surveys a species was detected. Eleven species were documented during our study and used in species richness analyses (Table 1). For abundance, we did not use two species (*Gastrophryne carolinensis*, *Pseudacris triseriata feriarum*), because there were insufficient data (i.e., detected less than five surveys) for analyses. Thus, our abundance results are restricted to common anurans.

On average, 95% (SD = 0.15) of species documented in 10 minutes were detected within the first 5 minutes of each survey (Fig. 1). Species richness was greater in 10-minute than in 5-minute

Table 1. Mean anuran species richness and relative abundance during 5- and 10-minute breeding call surveys, Cumberland Plateau, Tennessee, March–August 2005 and 2006.

		5-Minute		10-Minute		
Species[a]	N[b]	$\bar{X}$	SE	$\bar{X}$	SE	P-value[c]
Richness	321	2.49	0.06	2.62	0.06	0.17
ACCR	88	1.94	0.11	2.08	0.09	0.30
BUAM	20	0.90	0.12	0.95	0.11	0.76
BUFO	31	1.42	0.12	1.48	0.12	0.70
HYCH	57	1.89	0.12	1.93	0.12	0.84
PSCR	101	2.15	0.09	2.25	0.09	0.52
RACA	188	1.36	0.05	1.46	0.04	0.13
RACL	244	1.88	0.05	1.95	0.05	0.33
RAPA	79	1.35	0.08	1.45	0.07	0.35
RASP	47	0.69	0.08	0.87	0.07	0.07

a. Species documented were northern cricket frog (*Acris crepitans*, ACCR), American toad (*Bufo americanus*, BUAM), Fowler's toad (*B. fowleri*, BUFO), Cope's gray tree frog (*Hyla chrysoscelis*, HYCH), spring peeper (*Pseudacris crucifer*, PSCR), American bullfrog (*Rana catesbeiana*, RACA), green frog (*R. clamitans*, RACL), pickerel frog (*R. palustris*, RAPA), and southern leopard frog (*R. sphenocephala*, RASP).

b. We used 321 surveys for species richness analyses; sample size for relative abundance per species was equal to number of surveys it was detected.

c. P-values from ANOVA tests on mean differences between survey durations.

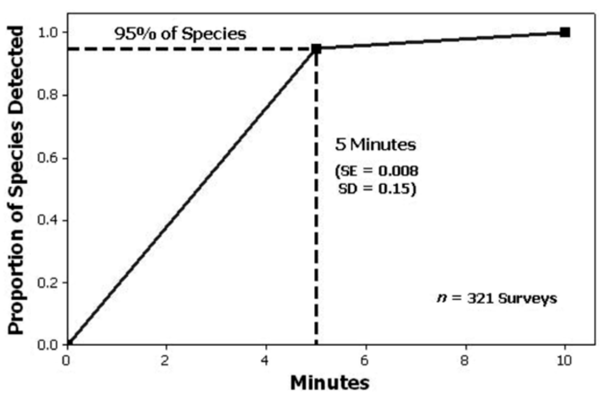

Figure 1. Species accumulation curve from anuran breeding call surveys, Cumberland Plateau, Tennessee, March–August 2005 and 2006.

surveys 11% of the time (Fig. 2); however, mean species richness was not different ($F_{1,656} = 1.9$, $P = 0.17$) between survey durations (Table 1). Similarly, species-specific abundance was greater in 10-minute than in 5-minute surveys 5%–28% of the time (Fig. 2); however, mean abundance did not differ ($F_{1,92} < 3.29$, $P > 0.07$) between survey durations for all species (Table 1). Mean species richness and relative abundance of northern cricket frog (*Acris crepitans*) and American toad (*Bufo americanus*) were different ($F_{1,38} > 4.94$, $P < 0.03$) between observers (Fig. 3).

Discussion

On average, after five minutes, 95% of species were detected. Mean species richness and relative abundance was not different between 5- and 10-minute surveys. Thus, our results suggest that anuran call surveys lasting five minutes are sufficient to detect most common anuran species in Tennessee wetlands, and increasing survey duration likely will not result in higher species richness or relative abundance estimates for local populations. Our results support Shirose et al. (1997) and the current standard duration of NAAMP and the Tennessee Amphibian Monitoring Program; however, they differ from Crouch and Paton (2002) and Pierce and Gutzwiller (2004).

Mechanisms driving differences in detection among studies are unknown but may be related to regional differences in species distribution, abundance, and wetland type (Pierce and Gutzwiller 2004). Although anuran species richness at our wetlands (11 species) was similar to previous studies (6–9 species), species composition was different. For example, only four species were similar between Pierce and Gutzwiller (2004) and our study. Detection can differ among species depending on calling behavior (de Solla et al. 2005), as species that call more frequently have a higher probability of detection (Crouch and Paton 2002). Forty-four percent of the species in our study could be classified as continuous callers compared to 22% in Pierce and Gutzwiller (2004). Also, amphib-

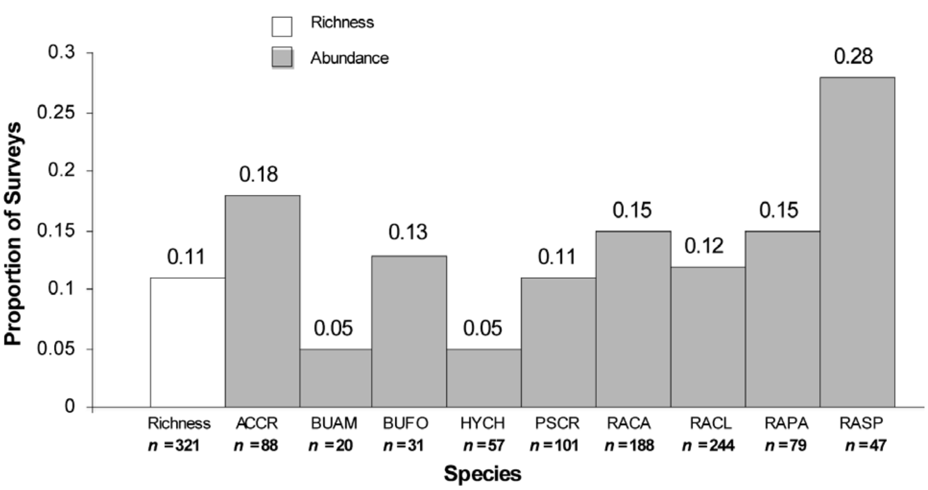

Figure 2. Proportion of breeding call surveys that anuran species richness and species-specific relative abundance were greater in 10-minute than in 5-minute surveys, Cumberland Plateau, Tennessee, March–August 2005 and 2006. Species documented were northern cricket frog (*Acris crepitans*, ACCR), American toad (*Bufo americanus*, BUAM), Fowler's toad (*B. fowleri*, BUFO), Cope's gray treefrog (*Hyla chrysoscelis*, HYCH), spring peeper (*Pseudacris crucifer*, PSCR), American bullfrog (*Rana catesbeiana*, RACA), green frog (*R. clamitans*, RACL), pickerel frog (*R. palustris*, RAPA), and southern leopard frog (*R. sphenocephala*, RASP).

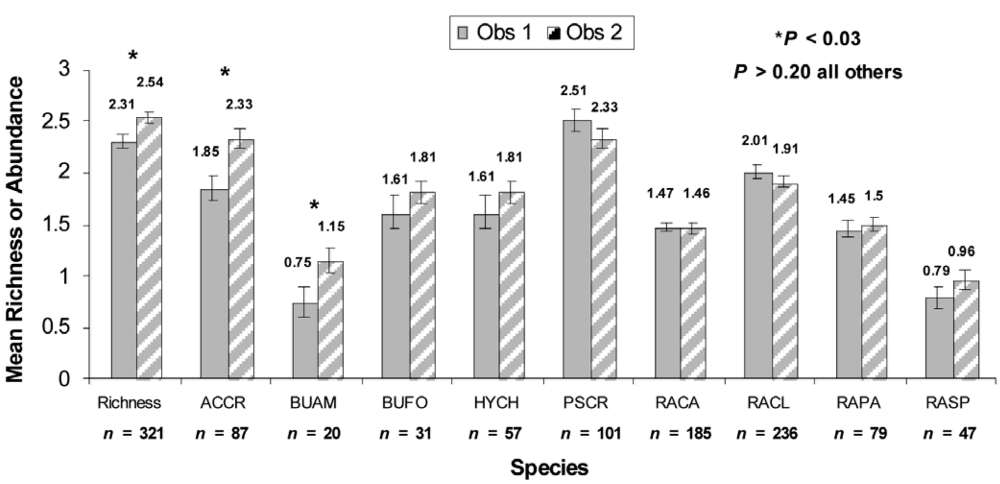

Figure 3. Mean anuran species richness and relative abundance between two observers (Obs 1, Obs 2) during breeding call surveys, Cumberland Plateau, Tennessee, March–August 2005 and 2006. Species documented were northern cricket frog (*Acris crepitans*, ACCR), American toad (*Bufo americanus*, BUAM), Fowler's toad (*B. fowleri*, BUFO), Cope's gray treefrog (*Hyla chrysoscelis*, HYCH), spring peeper (*Pseudacris crucifer*, PSCR), American bullfrog (*Rana catesbeiana*, RACA), green frog (*R. clamitans*, RACL), pickerel frog (*R. palustris*, RAPA), and southern leopard frog (*R. sphenocephala*, RASP). Means and standard error bars are presented, and asterisks indicate significant differences between observers.

ians at our wetlands may have been more abundant hence easier to detect (Royle 2004, Pellet and Schmidt 2005). Mean calling index was >1 for 78% of our species (Table 1) compared to 14% of the species for Crouch and Paton (2002). Finally, our study wetlands were relatively small and uniform in vegetation composition and structure. In contrast, Pierce and Gutzwiller (2004) surveyed reservoirs, rivers, and wetlands. Detection ability at reservoirs and rivers may be lower than at small emergent wetlands due to noise from wind and running water, respectively.

Mean species richness and relative abundance of northern cricket frogs and American toads differed between observers. Previous studies have documented differences in species detection based on observer experience (Shirose et al. 1997, Genet and Sargent 2003), though our two observers (ECB and ACS) had similar training (Tennessee Amphibian Monitoring Program workshop) and past experiences with call surveys. Indeed, calls of certain amphibian species can be more challenging to detect than others. The call of the northern cricket frog is a metallic clicking similar to a Geiger counter and in a chorus with other anurans can be difficult to detect (M. Gray, personal observation). Similarly, calls of the American toad is a high-pitch trill that can be difficult to hear at far distances or in multiple-species choruses (E. Burton, personal observation). These challenges may have contributed to differences in detection rates between observers for these species. Regardless, our results illustrate potential for multiple-observer bias in anuran surveys even with experienced observers.

Management Implications

We recommend that the Tennessee Amphibian Monitoring Program does not change duration of its anuran breeding call surveys from 5 to 10 minutes. The 5-minute NAAMP standard might be sufficient for other southeastern states but needs to be evaluated. Also, longer duration surveys may be appropriate for detecting rare species and those that call less frequently. Species detected in our study were relatively common, and many were continuous callers. Thus, coordinators of monitoring programs may consider a different call duration protocol for threatened and endangered anurans. Coordinators also should assign only one individual per monitoring route to avoid the possibility of multiple-observer bias.

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