The Journal of the Elisha Mitchell Scientific Society, 115(2), 1999, pp. 63–70

A COMPARISON OF ANURAN CALLING PATTERNS AT TWO CAROLINA BAYS IN SOUTH CAROLINA

JEFFREY R. MOHR[1] and MICHAEL E. DORCAS[2]
Savannah River Ecology Laboratory
Drawer E
Aiken, SC 29801

Abstract: Most male anurans use advertisement calls to attract females during their breeding season. While general breeding seasons are known for many species, temporal details of calling activity within the breeding season have been poorly described. Using an automated recording system, we compared the temporal calling patterns of five species of anurans [*Hyla cinerea* (green treefrog), *H. gratiosa* (barking treefrog), *Rana catesbeiana* (bullfrog), *R. clamitans* (green or bronze frog), and *Acris gryllus* (southern cricket frog)] between two different wetlands on the Savannah River Site, South Carolina. We recorded *A. gryllus* calling at all times during the day at both sites. Treefrogs (*H. cinerea* and *H. gratiosa*) called only during the early evening after sunset and *R. catesbeiana* and *R. clamitans* called primarily during the early morning hours before sunrise. Intensity was similar between sites for treefrogs and for *R. clamitans*; however, calling intensity for *R. catesbeiana* and *A. gryllus* differed between the two sites. *Rana catesbeiana* had a higher calling intensity at Flamingo Bay and *A. gryllus* had a higher calling intensity at Ellenton Bay. Presumably, variation in calling intensities of *R. catesbeiana* and *A. gryllus* reflect population size differences between the two wetlands which are likely related to differences in vegetation. Results of this study demonstrate variation in calling activity among species and between similar wetlands. Understanding such variation is essential for studies of anuran reproductive behavior. Additionally, data such as these can be used to optimize manual calling surveys, a major component of most contemporary amphibian monitoring programs.

Keywords: anurans; calling; automated recording system; Carolina Bay.

INTRODUCTION

Acoustic signals are used by many animals as forms of communication. Anuran calls are important for reproduction (Schiötz, 1973; Wells, 1977; Duellman and Trueb, 1986; Howard and Palmer, 1995; Bastos and Haddad, 1996) and proclaiming territory (Rosen and Lemon, 1974; Fellers, 1979; Arak, 1983). Calls are also sometimes used in distress situations (Schuett and Gillingham, 1990). The advertisement call, which is usually produced only by males, serves to both attract female conspecifics and deter potential competitors. Not only do characteristics of the call vary from species to species, but calling activity varies temporally and spatially as well. For example, some frogs may call 24 hr a day, while other

[1] Present address: Department of Biology, Furman University, Greenville, SC 29613.
[2] Present address: Department of Biology, Davidson College, Davidson, NC 28036.

species may call only at night (Blair, 1961). In this study, we examine the details of temporal variation in several anuran species. Our objectives were: 1) to measure temporal variation in anuran calling activity on the Savannah River Site, South Carolina, 2) to compare calling activity and species composition between two similar sites on the Savannah River Site, and 3) to evaluate resulting data in light of the development of anuran monitoring programs.

MATERIALS AND METHODS

We measured anuran calling activity at two Carolina bays on the Savannah River Site, South Carolina. A Carolina Bay is a natural, shallow depression of upland interstream areas of the southeastern Coastal Plain. Carolina Bays have unique features, including an elliptical or ovoid shape and a northwest/southeast orientation of the long axis. Carolina Bays contain hydric or mesic communities and range from lakes to shallow marshes, herbaceous bogs, shrub bogs, or swamp forests. The two bays used studied were Ellenton Bay and Flamingo Bay. They are located 11.6 km from each other, and thus experience similar weather conditions. Ellenton Bay was about 11 ha, has few trees in the bay, and was dominated by grasses and lily pads (*Nuphar advena* and *Nyphaea odorata*). Flamingo Bay, on the other hand, was half the size of Ellenton bay at 5.6 ha and had more trees and limited understory vegetative cover (Schalles et al., 1989).

Anuran calling activity was measured using automated recording systems from 24 June to 18 July 1998 (Peterson and Dorcas, 1992, 1994). Equipment consisted of a cardioid microphone (Model AT815A Audio Technica, Singapore) attached to a stereo analog tape recorder (Model TCD-5PROII, Sony Electronics, Park Ridge, NJ) controlled by a recycling timer (Model RS-1A12, SSAC, Baldwinsville, NY). This equipment, along with a voice clock (Model RS-63-915, Radio Shack, Ft. Worth, TX) to audibly time stamp the sampling period, was placed in a weather resistant toolbox. The microphone was shielded with plastic from 2-L soda bottles and affixed to nearby trees approximately 2 m off the ground at the water's edge and facing the center of each bay. High bias, type II cassette tapes (C-100CDT2A, Sony Electronics, Park Ridge, NJ) were used for recording. The timers were set to record 12 sec every 30 min, 24 hr per day for the entirety of the 25-day study.

Tapes were changed, every three days returned to the lab, played on a stereo cassette deck (Technics Model RS-TR232; Matsushita Industrial Co, Ltd., Singapore), and calling analyzed. Anuran calls were identified to species, and intensity was quantified as follows: 0 = no frogs calling; 1 = a single frog calling; 2 = a few frogs calling; 3 = loud chorus with many frogs. For all species other than *Rana catesbeiana* and *R. clamitans*, a "2" meant one could distinguish among individual calling males, and a "3" meant individuals could not be distinguished from the chorus. However, because of a low density of *R. catesbeiana* and *R. clamitans* at our sites, "2" meant two of that ranid species were calling and "3" meant that three or more were calling. Average calling intensity was calculated for each 24 hr period and cumulative calling intensity was derived by summing the call intensities for each 24 hr time period.

RESULTS

Five species of anurans were consistently heard throughout the study period. Three species were hylids: *Hyla cinerea* (green treefrog), *H. gratiosa* (barking

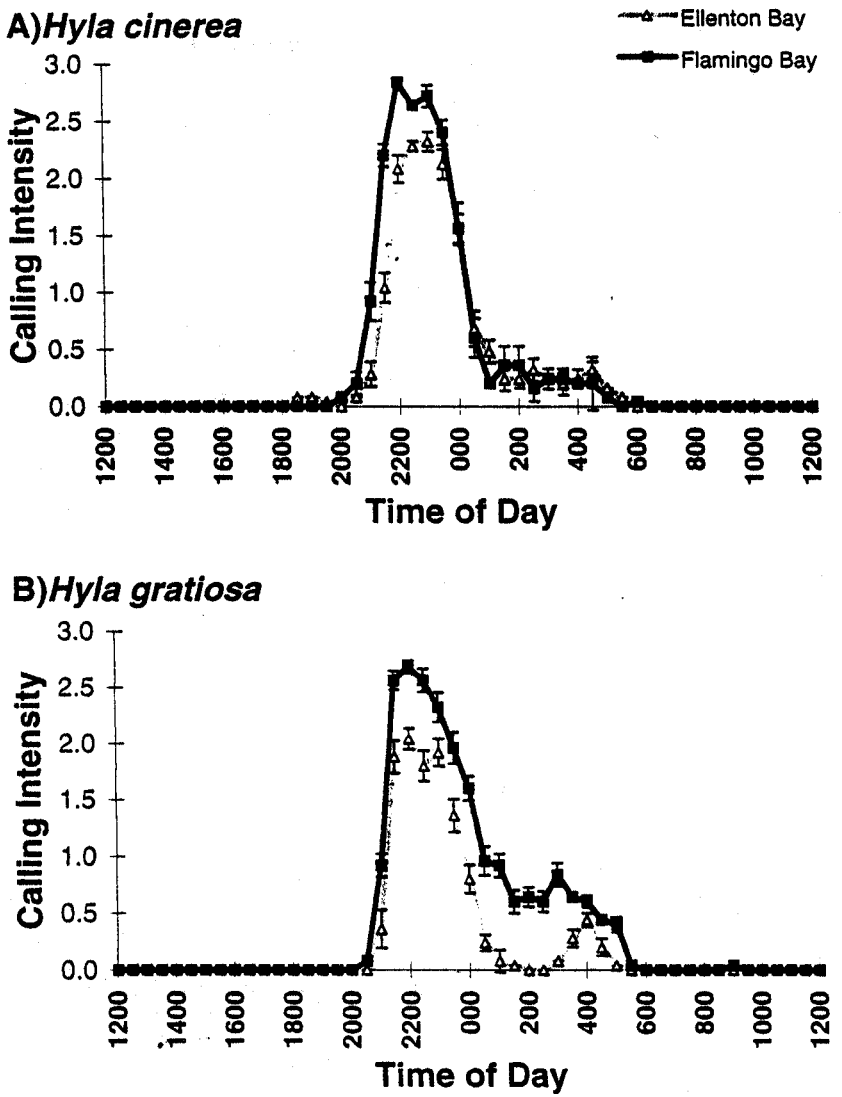

FIG. 1. Average daily calling intensity of *Hyla cinerea* (A) and *H. gratiosa* (B) during the 25-day study period. Bars equal ± 1 SE. Note that both species began calling at 2100 hr and ceased around midnight at both wetland locations.

treefrog), and *Acris gryllus* (southern cricket frog), and two ranids were also represented: *R. catesbeiana* (bullfrog) and *R. clamitans* (bronze frog). Two other species of anurans, *Gastrophryne carolinensis* (narrowmouth toad) and *H. femoralis* (pine woods treefrog), were recorded only rarely during the study. It should be noted these two species were only heard after rain, and *H. femoralis* was only heard at the end of the study period after a two-day period of rain.

Treefrogs usually began calling shortly after sundown (2100 to 2200) at both sites (Fig. 1). Calling intensity of *R. catesbeiana* and *R. clamitans* reached its highest intensity in the early morning hours from about midnight to 0600 (Fig.

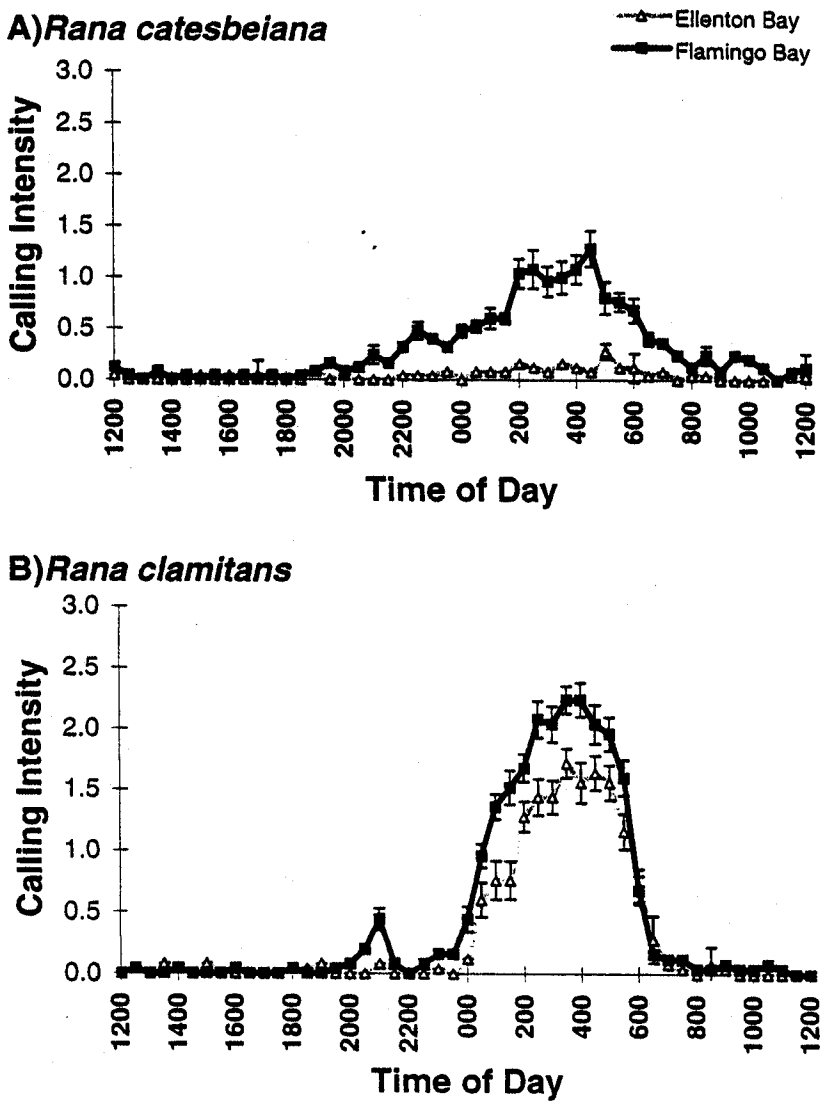

FIG. 2. Average daily calling intensity of *Rana catesbeiana* (A) and *R. clamitans* (B) during the 25-day study period. Bars equal ± 1 SE. Note that both species began calling at midnight and ceased around midnight at both wetland locations.

2), but for *R. catesbeiana* the increase was much greater at Flamingo Bay. *Acris gryllus* called consistently at all times during the 24 hr cycle, but increased calling was observed at Ellenton Bay between 2230 to 0330 (Fig. 3).

We also discovered considerable temporal differences in calling intensity over the 25-day study period between the two study sites. Both treefrogs and *R. clamitans* called at approximately the same intensity at both sites (Fig. 4). However, *R. catesbeiana* and *A. gryllus* had very different average intensities between the two sites (Fig. 5).

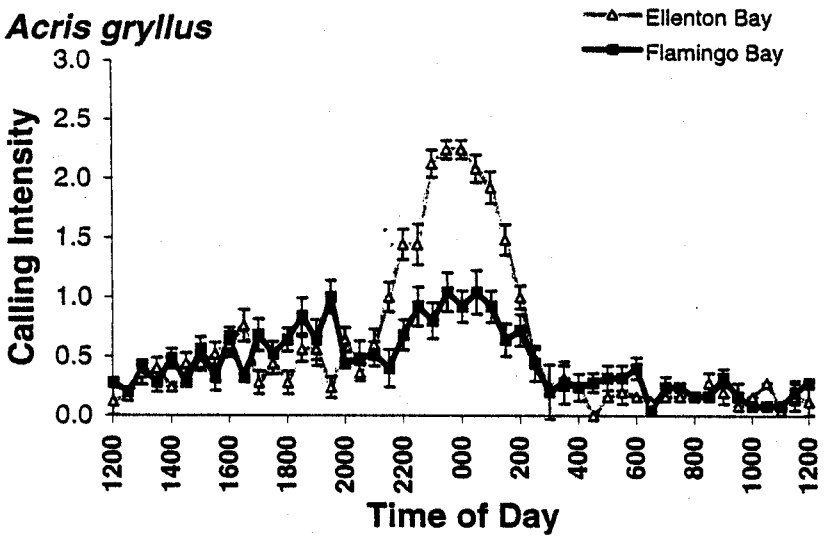

FIG. 3. Average daily calling intensity of *Acris gryllus* during the 25-day study period. Bars equal ± 1 SE. Note at both wetland locations *A. gryllus* called continually throughout the 24-hour period.

DISCUSSION

The automated recording system allowed us to study anurans in their environment with minimal disturbance and to sample anuran calls systematically over a long period of time, allowing us to draw several conclusions regarding temporal variation in anuran calling behavior. Treefrogs have a high intensity temporal calling period from 2100 to midnight. Past midnight, calling by treefrogs significantly lessened in intensity. In contrast, calling intensity in *R. catesbeiana* (only at Flamingo Bay) and *R. clamitans* did not peak until well after midnight (Fig. 2). The smallest anuran of the study, *A. gryllus,* called 24 hr a day, with an increase in average intensity at night only at Ellenton Bay. Comparisons of calling intensity at our two sites showed similar temporal results for all species. Thus, we conclude that temporal variation in calling behavior is not unique to individual sites of our study area.

Although the temporal calling patterns were similar between the two study areas, calling intensities of some species differed. Even though both treefrogs and *R. clamitans* had similar calling intensities at both sites studied (Fig. 4), this was not the case with *R. catesbeiana* and *A. gryllus*. Calling intensity of *R. catesbeiana* and *A. gryllus* was never equal between the two sites.

Flamingo Bay *R. catesbeiana*, has the higher calling intensity, while *A. gryllus* calling intensity was higher at Ellenton Bay. Assuming calling intensity is positively correlated with population size, the *R. catesbeiana* population is presumably larger at Flamingo Bay and the *A. gryllus* population is larger at Ellenton Bay (Fig. 5). A possible reason for differences in calling intensity, and thus population sizes, are differences in vegetative composition between the two bays. Flamingo Bay is a wetland with many large trees and limited amounts of understory vegetation and *R. catesbeiana* is known to prefer an aquatic, open habitat (Conant and Collins, 1998). The opposite is true for the small anurans such as *A. gryllus*.

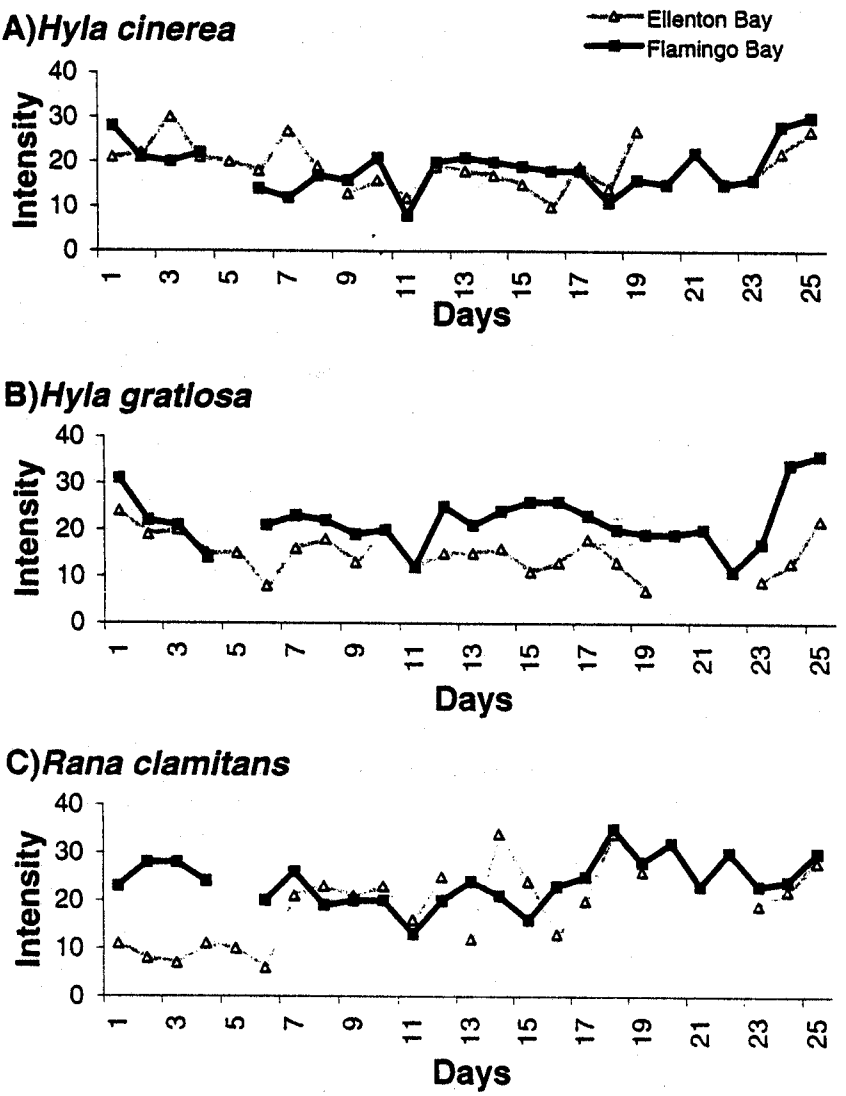

FIG. 4. Cumulative calling intensities for *Hyla cinerea* (A), *H. gratiosa* (B), and *R. clamitans* (C) during 25-day study period. Note the calling intensities were similar at both sites for all three species. Missing data on Day 5 at Flamingo Bay and Days 21–23 at Ellenton Bay is the result of equipment malfunction.

The ideal habitat for this small frog is grasses and lily pads (Conant and Collins, 1998), characteristic of Ellenton bay.

Manual calling surveys are a frequently used method of monitoring anurans. Data obtained using automated recording systems, such as in this study, can assist in the optimization of anuran monitoring programs that use manual calling surveys (Peterson and Dorcas, 1994). Automated recording systems provide the ability to collect data systematically over a long period of time with minimal disturbance to anurans. Automated recording systems are particularly useful in detecting spe-

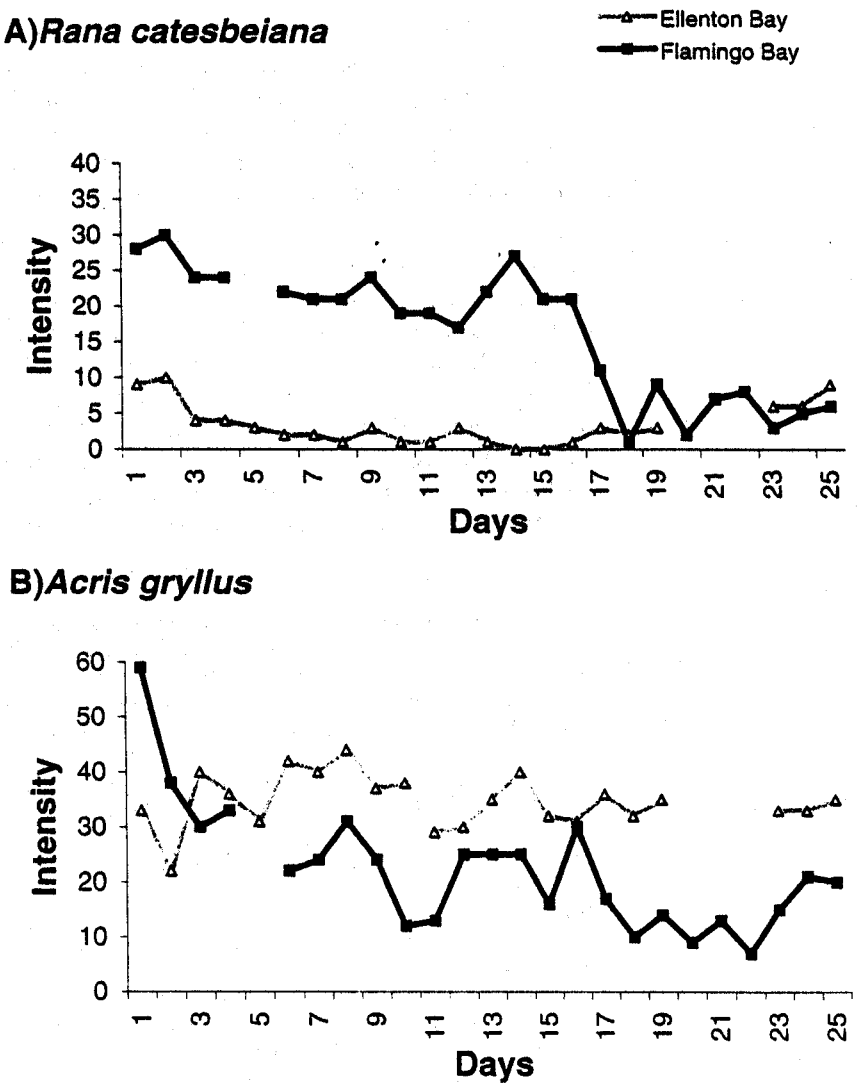

FIG. 5. Cumulative calling intensities for *R. catesbeiana* (A) and *A. gryllus* (B) during 25-day study period. Note the calling intensities were different between the sites. Missing data on Day 5 at Flamingo Bay and Days 21–23 at Ellenton Bay is the result of equipment malfunction.

cies that call late at night, which might be missed in manual calling surveys. In this study, if manual surveys were conducted during early evening, treefrogs would be detected, but ranids might not be. However, if one waited until early morning to conduct calling surveys, *R. catesbeiana* and *R. clamitans* would be perceived as abundant, yet the treefrogs would have likely ceased calling. Thus, if a certain species is targeted during a manual survey, data obtained from automated recording systems can be used to give a good indication of when the anuran in question is most likely to be heard.

Another advantage of automated recording systems over manual monitoring program is the ability to detect calls of infrequently calling species (Peterson and

Dorcas, 1992). For example, *H. femoralis* and *G. carolinensis* were only heard a few times during the 25-day study period. In fact, *H. femoralis* was only heard the last two days of the study and only after a two-day period of rain. If a manual survey were conducted during our study period it would be highly unlikely these infrequent calling species would be heard and thus the manual survey data would not include these species even though they inhabit the area.

Acknowledgments: Many of the concepts and ideas for our study are the result of collaboration with Charles R. Peterson. We thank J. Whitfield Gibbons, W. R. Teska, A. J. Pollard, and G. Cline for commenting on this manuscript. We also extend our gratitude to Caralyn Zehnder for changing tapes on a day when it was impossible for us to make it into the field. We thank Tracey Tuberville, Sean Poppy, and Angela Page and for their help with this project. JRM personally thanks Larken Euliss, Amy Holbo, John Ray, Jay Cumbee, Dee Dee Huff, and Janet Gorrell for their support throughout the project. This research was supported by Financial Assistance Award Number De-FC09-96SR18546 from the U.S. Department of Energy to the University of Georgia Research Foundation.

REFERENCES CITED

ARAK, A. 1983. Vocal interactions, call matching and territoriality in a Sri Lankan treefrog, *Philautus leucorhinus* (Rhacophoridae). Anim. Behav. 31:292–302.

BATOS, R. P., AND C. F. B. HADDAD. 1996. Breeding activity of the neotropical treefrog *Hyla elegans* (Anura, Hylidae). J. Herpetol. 30(3):355–360.

BLAIR, W. F. 1961. Calling and spawning seasons in a mixed population of anurans. Ecology. 42:99–110.

CONANT, R., AND J. T. COLLINS. 1998. Peterson Field Guides: Reptiles and Amphibians of Eastern and Central North America. Houghton Mifflin Co., Boston, Mass. 616 p.

DUELLMAN, W. E, AND L. TRUEB. 1986. Biology of Amphibians. Pp. 97–103. McGraw-Hill Co., N.Y.

FELLERS, G. M. 1979. Aggression, territoriality, and mating behaviour in north american treefrogs. Anim. Behav. 27:107–119.

HOWARD, R. D., AND J. G. PALMER. 1995. Female choice in *Bufo americanus:* effects of dominant frequency and call order. Copeia. 1995:212–217.

PETERSON, C. R., AND M. E. DORCAS. 1992. The use of automated data acquisition techniques in monitoring amphibian and reptile populations. Pp. 369–378. in D. R. McCullough and R. H. Barrett, (eds.), Wildlife 2001: Populations. Elsevier Applied Science, London.

———. 1994. Automated data acquisition. Pp. 47–57. in W. R. Heyer, R. W. Mediammid, M. Donnelly, and L. Hayek, (eds), Measuring and monitoring biological diversity-standard methods for amphibians. Smiths. Inst. Press, Washington, D.C.

ROSEN, M., AND R. E. LEMON. 1974. The vocal behavior of spring peepers, *Hyla crucifer*. Copeia. 1974:940–950.

SCHALLES, J. F., R. R. SHARITZ, J. W. GIBBONS, G. J. LEVERSEE, AND J. N. KNOX. 1989. Carolina Bays of the Savannah River Plant. National Environmental Research Park Publication. U. S. Dept. Energy, Savannah River Ecol. Lab., Aiken, S.C. 70 p.

SCHIÖTZ, A. 1973. Evolution of anuran mating calls ecological aspects. Pp. 311–319. in J. L. Vial (ed.), Evolutionary Biology of the Anurans. Univ. Missouri Press, Columbia, Mo.

SCHUETT, G. W., AND J. C. GILLINGHAM. 1990. The function of scream calling in nonsocial vertebrates: testing the predator attraction hypothesis. Bull. Chicago Herp Soc. 25:137–142.

WELLS, K. D. 1977. The social behavior of anuran amphibians. Anim. Behav. 25:666–693.

Received 8 December 1998