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A Passive Monitoring System for Anabat II Using a Laptop Computer

Michael J. O'Farrell. O'Farrell Biological Consulting,
2912 North Jones Boulevard, Las Vegas, NV 89108

Introduction

Anabat ultrasonic detection and analysis equipment (Titley Electronics, New South Wales, Australia) provides a relatively inexpensive way to examine the time-frequency structure of echolocation calls that have been recorded using a low-cost tape recorder. A number of studies have used such equipment to monitor activity of bats (Hayes and Adam, 1996; Humes et al., in press; Krusic et al., 1996; Lance et al., 1996; Mills et al., 1996); however, these workers reported an inability to identify all species recorded, particularly those of the genus Myotis. Additionally, tape recordings generally resulted in sequences of few usable calls, many of which were fragmentary (Mills et al., 1996).

An alternate approach incorporated the use of a laptop computer as a substitute for the tape recorder (O'Farrell et al., 1999). Digitally storing calls as binary computer files eliminated distortion due to differential tape speed and general background noise inherent in inexpensive tape recorders. In the past, use of the computer required the presence of an investigator to save files manually. This active approach (investigator present) was beneficial because it allowed the investigator to examine calls in real time, make adjustments to sensitivity to reduce echoes and other noise, and selectively save high-quality sequences. However, need for the investigator's presence limited the number of sites that could be monitored simultaneously.

Newer versions (5.7 and higher) of the Anabat software provide an "automatic save" capability that places a sequence of calls into memory about 5 seconds after incoming sounds terminate. An investigator, therefore, can implement the automatic save function, leave the computer to tend mist nets or traps, and not lose acoustic information. With a computer and zero-crossings analysis interface module (ZCAIM), separate sites can be monitored simultaneously. Over the past year, I experimented with passive monitoring (investigator absent) techniques using the automatic save mode. The purpose of the present paper is to describe various methods used, including modifications that allow safe monitoring during inclement weather.

The System

I used the passive system to monitor areas over stock tanks, earthen impoundments, riparian or riparian-scrub corridors, and along rocky hillsides. One must select an area that is secure from vandalism yet allows for orientation of the equipment to cover the most likely flight path of bats. To date, I have not experienced vandalism or damage by animals. Although many configurations are possible, I used the following materials and arrangement.

A 53-liter plastic container (Rubbermaid Roughneck) held all equipment, including the Anabat detector, ZCAIM, laptop computer, and external battery (Fig. 1). The system also used a piece of electrical conduit made from polyvinylchloride (PVC) and having a diameter of 5 cm; the conduit was an "elbow joint" manufactured with a curved 90° turn. The conduit was fitted through one end of the container and adjusted to orient the external opening of the elbow at about 45° to the ground. The detector microphone was placed in the other opening. The microphone end of the conduit was modified by making a slanted cut, starting 10.2 cm from one end on the inside bend and extending to 11.5 cm from the end on the outside bend; this allowed the detector to fit into the conduit with the lid of the container closed. A small hole (10-mm diameter) was drilled at the bottom of the turn to allow drainage of water. A 4-l, rectangular, plastic container (Rubbermaid) was used to hold an AC adapter and inverter for the computer. Three holes (38-mm diameter) were cut along each of the long sides of the 4-l container to provide ventilation and egress of the power cord to the battery and computer. Once set up and all electrical connections made, the computer was turned on and placed in automatic save mode using Anabat software.

The lid of the computer should then be closed. Closing the lid automatically turns off some computers thereby reducing energy consumption and increasing battery life. If the screen does not automatically turn off upon closure, the ZCAIM cannot be placed directly on the lid of a laptop because electrical noise is generated by continued operation of the computer screen. Separating the ZCAIM from the computer lid with a ca. 6 cm of foam rubber allowed use of even these computers.

This system was tested during high wind and rain in Wyoming on 13-16 June 1998 during conditions that were severe enough to rip a rainfly off a backpacking tent. The passive monitoring setup was secure, all equipment remained dry, and good sequences of echolocating bats were recorded during periods throughout the night. Since then, the setup has been used during a variety of weather conditions, including cool nights with heavy condensation, and has provided complete protection for all electrical components.

The capacity of the battery to operate a laptop for more than one night depends on size of battery used. The current that is drawn is highly variable from one model of laptop to another. Older refurbished machines tend to be less efficient and draw more current. For example, the variation in my current laptop computers is as follows: Clincher notebook, 2.33 amps; IBM Thinkpad 360CSE, 4.13 amps; Toshiba Satellite T2130CS, 1.65 amps. Closing the computer decreased draw on the Toshiba to 1.02 amps but had no effect on the draw of the two older computers. If there is access to AC power, recharging batteries on a daily basis is accomplished easily. However, difficulty arises at remote locations, and use of a small generator may be required. I am currently experimenting with use of a RAM drive to decrease current draw even further, and preliminary results indicate a draw of only about 0.8 amps when the hard drive is shut down.

I originally used a deep-discharge marine battery (Astro Lite 24EV, 85 amp-h, weighing 21.1 kg). With this battery, the Clincher notebook could be powered for 25 h. I more recently incorporated the use of a more lightweight, wheelchair battery (Guardian DG 12-32, 32 amp-h; 11.6 kg) that provided 12 h of use by the IBM Thinkpad. Greater ease in transporting the smaller battery compensated for the shorter duration of use. A 6-amp automatic charger completely charged the wheelchair battery in less than 8 h.

Effect of Conduit on Detector Response

Difference in response for an unenclosed detector microphone and one placed in the conduit was tested in two ways. First, distance and angle of response was determined using an electronic tape measure (Radio Shack, Catalog #63-645, Tandy Corporation, Fort Worth, TX). This device produced pulses that roughly oscillate from 47-49 kHz. Technical specifications stated the range of the tape measure at 15 m, and electronic pulses were detected up to that distance. Electronic pulses were detected consistently within a 45° cone of reception regardless of whether the microphone was exposed or within the conduit. Occasional pulses were detected beyond 45° but probably represented echoes from nearby trees.

Second, quantity and quality of echolocation calls was determined by recording bats simultaneously with two detectors--one exposed and the other in the conduit. The two-part test was conducted at Grapevine Spring, Clark Co., Nevada, on 15 September 1998. Each detector was attached to a separate ZCAIM and laptop computer. To test for differential in response between detectors (Test 1), the two detectors were strapped together, oriented at a 45° angle, and used simultaneously to monitor bat activity for 0.5 h. To test the effect of collecting sounds by an exposed vs. an enclosed detector (Test 2), one detector was placed in the conduit (Fig. 1), and the other was strapped to the outside of the conduit so that the microphone was even with the extended opening of the conduit. Simultaneous monitoring continued for another 0.5 h.

Approximately equal numbers of files were collected during each test (Table 1). Four species of bat were detected during Test 1 (*Pipistrellus hesperus*, *Myotis californicus*, *M. ciliolabrum*, and *M. thysanodes*). Two additional species were detected during Test 2 (*Antrozous pallidus* and *M. volans*). Detector 1 collected significantly more individual calls than Detector 2 during both tests, with and without use of the conduit (Wilcoxon Signed-Rank tests, $P < 0.01$). However, the proportion of calls collected by Detector 1 compared with Detector 2 remained constant between tests, suggesting that the conduit had no effect on response of the detector.

During Test 1, Detector 1 collected three files that were not recorded by Detector 2, and Detector 2 collected one file that Detector 1 did not. The same species were detected by both detectors, and no apparent difference in ability to identify species existed between recordings produced by the two detectors.

During Test 2, each detector collected one file not recorded by the other machine. At 1948 h, Detector 2 recorded 13 calls of *M. thysanodes*, whereas Detector 1 did not record any file. At 2008 h, Detector 1 recorded two calls of *M. californicus*, but no file was recorded by Detector 2. In addition, Detector 2 collected one file that consisted of unidentifiable noise, during the time that the other detector recorded 24 calls of two species. Enclosed and unenclosed detectors generally recorded the same species; however, Detector 2 (in the conduit) was the only one to record M. thysanodes during Test 2. Visually, there were no apparent differences in clarity of the time-frequency structure between calls recorded by unenclosed or enclosed (conduit) detectors.

Field Use

Since July 1997, I have used the passive setup over metal tanks in open pinyon-juniper woodlands (Shingle Spring, Lincoln Co., Nevada; Summit Spring, Washington Co., Utah), along riparian corridors (Virgin River, Clark Co., Nevada; Lake Perris State Park and Sycamore Canyon Wilderness Park, Riverside Co., California; Henry's Fork, Sweetwater Co., and Boysen State Park, Fremont Co., Wyoming), over large earthen ponds (Volcan Mountain Wilderness Preserve, San Diego Co., California), and along rocky hillsides (Lake Perris State Park, Riverside Co., California; Lower Sage Creek, Sweetwater Co., Wyoming). The percentage of files that contained sequences of calls that were of sufficient quantity and quality to identify species was generally high and similar whether the conduit was used or not (Table 2). The low percentage of usable sequences at Simmons Flat (66.5%) appeared associated with the open nature of the site.

To obtain sequences of calls of sufficient quality and quantity for species identification, it is necessary to orient the microphone to maximize the time a bat remains within the cone of reception. This can be accomplished by orienting the equipment to cover areas suspected of concentrated bat activity. Thus positioning the microphone to point over a pond or water tank, along the edge of a riparian corridor, and within a flight path have resulted in more identifiable sequences than orienting the unit straight up or perpendicular to vegetation edges. Placing the detector within 30 cm of the ground and oriented at a 45° angle provides a cone of reception that will sample bats well from the ground to directly overhead at a distance of 2 m or greater from the microphone. Use of the automatic save function in Anabat software (versions 5.7 and higher) with a laptop computer provides a greater ability not only to monitor bat activity remotely but also to identify the species of bats. The current availability of inexpensive, refurbished laptop computers provides an economical option for passive monitoring

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Table 1. Summary of mean number of calls recorded with both detectors unenclosed (Test 1) and a combination of one unenclosed and the other placed in a conduit (Test 2). N = number of files collected.

	TEST 1		TEST 2	
	Detector 1	Detector 2	Detector 1	Detector 2
	Unenclosed	Unenclosed	Unenclosed	In conduit
n	29	29	27	27
Mean	35.1	29.6	23.0	19.7
SE of Mean	5.93	4.96	4.43	3.66
Range	4-130	2-111	4-118	0-96

Table 2. Summary of total number of files recorded during passive monitoring with the number of files containing sequences of calls that were inadequate for identification of species (non-usable) and the percentage of files with identifiable sequences (% usable).

Location	Total	Non-usable	% Usable
A With Conduit			
Lake Perris State Park, CA	193	42	78.2
Sycamore Canyon Wilderness Park, CA	22	2	91.0
Simmons Flat, Volcan Mtn., CA	272	91	66.5
Virgin River, NV	150	21	86.0
Shingle Spring, NV	2,357	298	87.4
Summit Spring, UT	495	0	100
B Without Conduit			
Ferguson Pond, Volcan Mtn., CA	982	100	89.8
Boysen State Park, WY	49	10	79 6
Lower Sage Creek, WY	28	1	96 4
Henry's Fork, WY	175	22	87 4

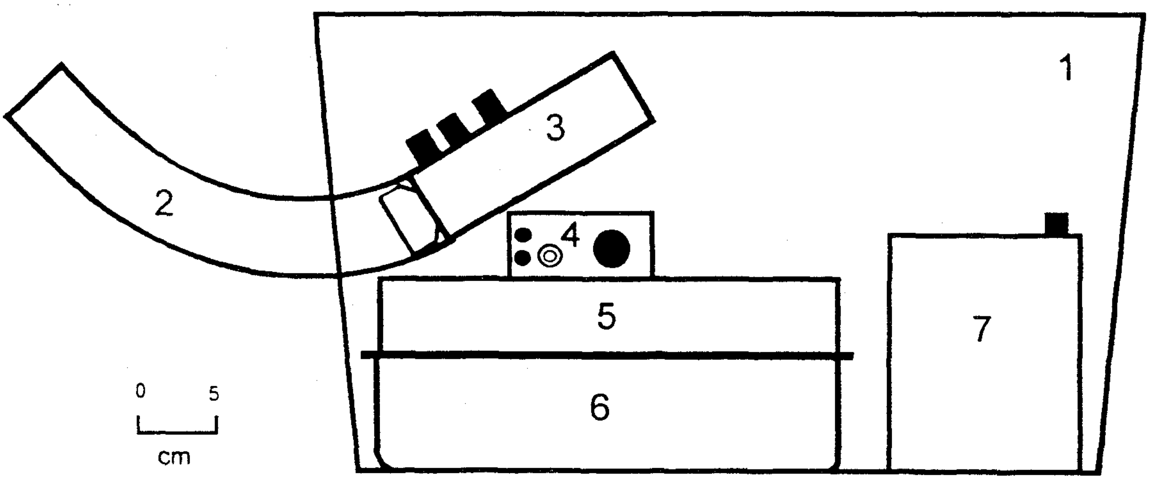

Figure 1 Diagram showing arrangement of passive-monitoring system. 1 = 53-l container; 2 = 5-cm diameter electrical conduit with 90° bend; 3 = Anabat detector; 4 = ZCAIM; 5 = laptop computer; 6 = 4-l container, 7 = 12-volt sealed battery

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