

## A STUDY OF ACOUSTICAL CONFUSION

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### ABSTRACT

*Bats are critical to maintaining a stable and healthy environment in their role as predators of insects and pollinators of plants. Several species have become endangered due to the disruption of the bat habitats in eaves caused by human intrusion ranging from field studies of cave environments and archaeological digs, to recreational excursions, and vandalism. Gating of caves has been used for many years as a last-resort effort to protect the bats providing for movement of the bats while restricting entry of humans. Many of the gates, however, have adversely affected the bats, including leading to the abandonment of some eaves. It is not known why some gates work with some species and in some caves while others do not.*

*A study was initiated by the author in the spring of 1991, with support from various governmental agencies, to research this problem. Caves populated with the endangered gray bat (*Myotis grisescens*) were studied in Alabama, Kentucky, and Virginia. Bat movements were monitored at cave sites with gates and without gates. An analysis is also being made of the various cave environments and the location of the gates within the caves. The hypothesis being tested by this researcher is that gates create acoustical confusion and slow the passage of the bats through the gates. This confusion becomes acute when large populations inhabit the cave and maintain high traffic.*

*The anticipated outcome of this study was to determine cave gate specifications and provide recommendations for future cave gate designs. Specifically, the findings could: 1) provide specifications for the size of cave gates (full and half sizes) needed for a given populations of bats, and 2) provide determinations of the location of cave gates (light or dark zones) for a given population of bats.*

### INTRODUCTION

This study was initiated in the spring of 1991 and field work was conducted through the fall of 1993. The study was funded primarily by the Natural Heritage Division of the Tennessee Valley Authority and was supported by various other state and governmental agencies. Gating of eaves has been used for many years as a last resort effort to protect bat colonies by providing for the movement of bats while restricting entry of humans. Many of the gates, however, have adversely affected the bats, including abandonment of some sites. It is not understood why some gates work with some species at some sites while others do not. The hypothesis being tested by the researcher is that gates create acoustical confusion and slow the passage of the bats through the gates and that this confusion becomes acute when large populations inhabit the cave

and maintain high traffic in and out of the site. Caves populated with the endangered gray bat (*Myotis grisescens*) were studied in Alabama, Tennessee, Kentucky and Virginia.

### METHODOLOGY

Audio recordings were made at selected gray bat cave sites on a stereo recorder. The heterodyned output of a bat detector was recorded on one channel and the divided output of the full frequency range was recorded on the second channel. The frequency selection of the heterodyned signal was sometimes varied from the natural frequency of 42.5 kiloHertz (kHz). The tapes were then analyzed by studying the wave forms. The frequency range and relative sound intensities were measured.

<b>Table 1: Sites Studied</b>		
Hubbards Cave	Tennessee	(Hibernaculum, CCI angle-iron gate)
Pearsons Cave	Tennessee	(Hibernaculum, no gate)
Sauta (Blowing Wind) Cave	Alabama	(Maternal, round-bar gate)
Collier Cave	Alabama	(Abandoned maternal, CCI angle-iron gate)
Riders Mill Cave	Kentucky	(Maternal, no gate)
Grigsby Cave	Virginia	(Bachelor, no gate)
Speers Ferry Cave	Virginia	(Bachelor, no gate)

Three of the study eaves with large gray bat populations have been successfully gated (Hubbards, Pearsons, and Sauta).

The Hubbards Cave site has a large cross-sectional area. The gray bats roost in an un-gated portion of the cave until they gradually move behind the gate in the fall. The geometry of the cave allows the gated portion to be avoided during the period of high activity prior to hibernation, and allows the bats to move to the protected hibernation site over a period of time and in smaller numbers. This indicates that the bats cannot or do not like to use the gate in large numbers.

The Pearsons Cave site has one horizontal and two vertical entrances. Only the small horizontal entrance is gated. No bats were observed using the gated entrance during the study. However guano in front, behind, and on the gate suggests that there is a limited amount of occasional use. As at Hubbard Cave the geometry of the cave gives the bats an option of not using the gate during periods of high activity.

There are two entrances to Sauta Cave. The upper entrance has a full-height, round-bar gate and the lower has a half gate also of the round-bar type. The vast majority of bats use the lower entrance, flying above the gate. Observation at both entrances suggest that the bats use these gates with great difficulty. Bats at both entrances were observed to collide frequently with signs located behind the gate.

The Collier Cave site has a full-height Cave Conservation International (CCI) angle-iron gate. Collier Cave was gated after traffic had driven the

maternity colony to abandon the cave in favor of another nearby cave. The gate was installed as an experiment to see if the colony could be reestablished. The bats returned for a short period of time after the traffic was reduced but they roosted in front of the gate. Only a few gray bats were observed using the gate.

Speers Ferry Cave has two entrances and is ungated. A large transient colony of about 15,000 to 20,000+ uses the cave in the spring and fall for a few days most years. The population of this colony is assumed to consist of both males and females. The cave also has a summer population of several hundred males.

Grigsby Cave has only one entrance and is ungated. The summer population varies between 1,000 and 6,000 gray bats. Some years all gray bats leave the cave by the end of June. It is suspected that when the numbers are low during the summer that the site is strictly a bachelor colony site and when the numbers are high that a maternity colony may be present.

Riders Mill Cave is a maternal site and is ungated. It was visited during the investigation to determine if the gray bats using the cave behaved differently than those at other sites.

### ***The Bandwidth Phenomenon***

The investigator had noticed on several occasions when using a bat detector to monitor gray bat emergences that the frequency range used by the bats appeared to increase from the natural frequency of 40 to 43 kiloHertz to 20 to 200+ kiloHertz. This increase

will be referred to as the bandwidth phenomenon. Part of this phenomenon could be explained as a result of signal clipping within the detector. When the detector amplifier circuits become overloaded, the peaks of the signal are clipped. Clipping results in the signal approximating square waves and the generation of odd harmonics. The investigation of this phenomenon was a primary focus of this study. Two questions were to be answered. The first was why the phenomenon occurred and the second was if it were possible to use the phenomenon as a tool to determine what sites could be successfully gated.

## RESULTS

The bandwidth phenomenon was observed at all sites. Observations made with care given to the avoidance of clipping, revealed that there was a real increase in bandwidth. Observation also showed that this increase was accompanied by an increase in milling and was related to the cross-sectional area of the entry and the number of bats attempting to use the entry.

A gray bat emergence usually begins with a single bat and is detected with the bat detector at a frequency about 42.5 kiloHertz. As more bats emerge the frequency range increases at a rate that is related to the number of bats. At the peak of the emergence the frequency range and the intensity of the sound is at the highest level. When the number of bats is small, individual bats can be distinguished at frequencies other than 42.5 kiloHertz. No harmonics are detected during this condition. As the number of bats increase and the intensity increases, harmonics (other than those created in the equipment) are probably present. When the signals are observed on an oscilloscope, individual bats can be distinguished when the number of bats is small, but when the signals of large numbers

are observed the display resembles noise and individual signals can be observed only with a storage display. When the signals are subjected to a spectrum display, with detector over load eliminated, some higher frequencies have a higher amplitude than lower frequencies.

## CONCLUSIONS

This study indicates that when a large number of bats attempt to use an entrance (or a gate) an individual bat cannot easily distinguish its own echo from that of another bat. The bat therefore changes the amplitude and/or frequency of its call. The bat is receiving its own signal, the sounds, and the echo of the sounds of other bats. The result is confusion and inability to determine a safe exit route. The bat is then forced to mill about until it has a clear audio picture of the entrance or obstruction. An analogy of this situation would be an individual trying to understand what another individual is saying from across a room of people all talking at once. This condition will be called acoustical confusion. The inability of the colony to rapidly exit a site creates stress. The maternal gray bat must eat enough in order to support herself and her young. She must have easy and rapid access to the foraging area and for this reason the maternal colony will naturally be very sensitive to gates.

Although limited, the results of this study indicate that there is a direct relationship between the size of the population and the usable cross-sectional area of the passageway and that sites that meet all other environmental requirements suitable for bat habitation are limited to specific populations by the size of entry or passageway. When that size is reduced by obstruction, such as a bat gate, the population may find the site unsuitable for habitation.