Making animal sound recordings

An introduction to the science—and art—of recording and annotating bird and other animal sounds

by Richard Bradley[1]

Introduction

BIOACOUSTICS, the study of animal sounds, has come into active focus relatively recently. Although some valuable work was done on a variety of species prior to the 1940s, most of the research in this field began with the introduction of easily portable sound recording equipment in the mid-1950s.

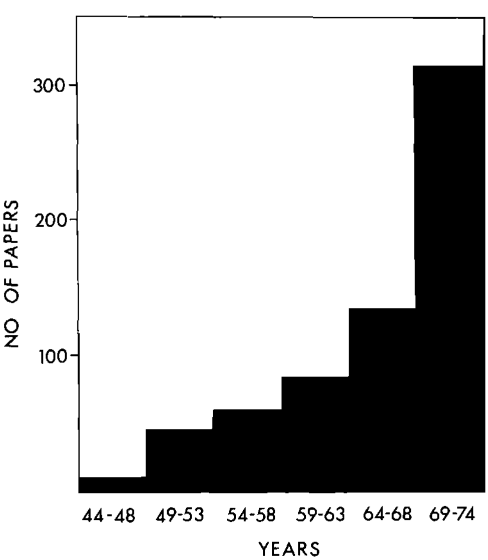

Figure 1. Growth in bird song research as indicated by the number of technical papers published since 1944

Nearly all early work in bioacoustics, as well as much of the current literature, deals with three major groups; insects, anuran amphibians, and birds. A quick tally of papers dealing with acoustic communication in birds demonstrates the rapid growth in this field (Fig. 1). With the tape specimens in hand, workers can carefully and objectively analyze acoustic signals used by animals for communication. Currently, work in bioacoustics is expanding rapidly into almost every taxon and most environments. New recording equipment has opened up the underwater acoustic environment as well as the ultrasonic and subsonic ranges.

Amateurs as well as professionals are producing an increasing number of new recordings, many of which have great potential value. Unfortunately, few workers are careful to include all pertinent data necessary to complete a specimen. This paper is meant to serve as a guide for both the serious student and the casual recordist to insure that their recordings are valuable scientific specimens.

Many people are familiar with recordings of animal sounds now available on commercially published phonograph discs. Although

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these discs perform a useful service, they are of secondary importance to scientific investigators. Most of them are produced from recordings housed in various private and institutional sound archives, and are usually presentations of typical examples of well documented sounds. Perhaps the most famous sound archive, established by Peter Paul Kellogg and Arthur A. Allen, is housed at the Laboratory of Ornithology, Cornell University. Many other fine archives exist, and scientific animal sound specimen collections have mushroomed in recent years. A preliminary list of sound specimen collections is presented by Boswall (1974). Sound specimens are catalogued in the same general way as in other scientific collections. Complete recording data are kept with the specimens, including notes on the specific behavioral context in which the vocalization was given.

The material in sound archives is used by investigators in a variety of fields including ethology, ecology, taxonomy and evolutionary biology. Although hundreds of field recordists have recorded miles of tape specimens, much basic information remains to be documented. In fact, sound specimens have probably been obtained for fewer than half of the known species of birds, the best documented taxon. The vocal performances of myriads of tropical insects, amphibians and mammals are totally undocumented. Recorded specimens from aquatic animals are barely represented. Many of these forms have complex and interesting acoustic behavior. Amateurs can perform a valuable service by contributing well documented recordings of animal sounds to scientific collections.

[Definitions of technical terms italicized in the text may be found in the glossary, page 285].

General Methods

PRACTICALLY SPEAKING ALL MODERN work in bioacoustics involves recording of animal sounds onto magnetic tape. The great variety of tape recording equipment now available ranges from barely suitable to highly sophisticated. The type of equipment used depends upon convenience of operation, portability as well as monetary limitations. Professional recordists are constantly changing their machinery and techniques to conform to the flux in the "state of the art" in electronics. This does not mean that others limited to less sophisticated equipment cannot produce valuable recordings. On the contrary, excellent recordings can now be made by the serious amateur on equipment that is readily available on the retail market for under $300.

Two basic types of tape recorders are in use today. One type uses narrow (⅛ in.) magnetic tape enclosed in a sealed unit called a cassette (not to be confused with a cartridge). Another type uses tape threaded between two separate plastic reels, and is usually referred to as open reel or reel-to-reel recorder. I will discuss the relative characteristics of these two groups below. Although investigators occasionally make recordings of their subject in a laboratory, this paper deals with equipment and techniques for work in the field. In addition to the many different tape recorders, an equally confusing array of microphones can be used in bioacoustics. The specific type of recorder and microphone appropriate for any given situation depends upon the type of organism being recorded as well as its surrounding environment.

Naturally most workers would like to produce "clean" recordings of an organism's sound, i.e. without extraneous background noise. However, some noise is usually unavoidable. In fact, weak recordings of a rare phenomenon are often more valuable than beautiful clear tapes of more common sounds. The use of modern laboratory audio equipment can often transform so-called "useless" recordings into valuable specimens.

Field Notes

PUTTING DATA WITH a specimen is perhaps the single most important step in bioacoustic recording. It is critically important that as much data as possible be recorded onto the tape at the time of recording. In this way the actual specimen and associated data are physically linked and confusion or transcription errors are far less likely. Some identification information should be included on the tape to avoid confusion, although notes put on a tape may often be supplemented by written field notes. Objections to this technique involve "wasting" tape for voice comments by the recordist, but experience with reels of "no data" recordings has convinced me of the importance of putting data on the original field tape.

The minimum data that should be recorded on the tape includes: the name of the organism, the location, date, time and weather data where possible. Additionally, it is important to add notes on the context of the vocal behavior. In some cases a statement like "singing from the top of a bare tree" is sufficient. In other cases a description of a particular display or interaction may be more appropriate. The more relevant data that are included, the more valuable is the specimen. Most recordists will not wish to "talk on top of" their recordings. Unless one has the facility for recording a separate voice track simultaneously, it is customary to wait for a pause in or the end of a recording for notes. A short note giving the name of the organism is often inserted near the beginning of a particular *cut*. This will aid during the cataloging procedure.

Use of an organism's scientific name is preferred over its common or vernacular designation. If the vocalizer is not seen, this should be noted because, at least in the case of birds, imitation is often a possible source of misidentification. The location should be described as the distance and direction from a town or city, or other geographic landmark, or coordinates. The country, state and county should be included where appropriate. Weather data should indicate sky and wind conditions and air or water temperature. In the case of amphibians it is particularly important to take temperature readings from the water if the subject is partly submerged.

For convenience a shorthand notation may be used. The location, date, and weather data may be recorded once for a given field tape, often at the beginning. The time of each recording is then added for each *cut* as well as any notes on changes in the weather. With a little practice, full data can be added to a specimen using only a few feet of tape.

Tape Recorders

THE TWO BASIC TAPE systems used in bioacoustics are the cassette and open reel systems. Cassette recorders have been shunned for many years for high quality recordings because of several inherent problems.

Early cassette machines had several disadvantages. The most important was the slow tape speed which is used for all cassette recorders—1.5 inches per second (ips). The upper *frequency response* was usually limited to about 8000 *Hz*. Tape speed control was also poorer than open reel machines operating at higher speeds. The thin tape used in cassette recorders often resulted in a poor *signal-to-noise ratio*. These two problems have been largely eliminated in cassette technology, and modern high quality portable cassette decks are available that yield superior results. These are often more compact and convenient than the standard open reel machines.

One important factor in this improvement has been the development of chromium dioxide cassettes. The chief complaint remaining is that cassette tapes are difficult to edit compared to open reel tapes. Open reel machines are usually heavier and less convenient to operate. The finest open reel machines still maintain somewhat superior quality to the best cassette machines.

When selecting a tape recorder one must balance quality and convenience against economic factors. In general, inexpensive open reel machines give better performance than inexpensive cassette machines. Relatively inexpensive cassette recorders such as the Sony C-108 (*ca* $150) are probably the best bet for the occasional recordist. For more serious investigators who wish to have good quality at a reasonable price, the Uher 4200 (*ca* $675) and Tandberg II (*ca* $800) are popular open reel models. Fine professional quality portable open reel units such as Nagra IV-SD and Stellavox SP-7 are available for those who can afford to spend around $4000. For an excellent review of the available equipment (recorders, tapes and microphones) consult the 1976 tape equipment buyers guide published by High Fidelity magazine (Tynan 1975).

Open Reel Recorders

OPEN REEL TAPE RECORDERS come in a bewildering variety of styles. One of the important features one must select when choosing any tape machine is the tape head configuration. Monophonic recorders using standard ¼ in. tape now come with two basic configurations. The first, full track, refers to machines that use the entire ¼ in. tape width for the signal. With this sort of machine one gets the best possible recording characteristics. Since there is only one channel there cannot be any *cross talk*. Obviously one can use only one side of the tape, since if one turned the tape over to record the back side, it would erase the previously recorded signal. The other standard type is called ½-track. These machines use half of the ¼ in. tape width. This leaves the other half free for recording a second track by turning the tape over and recording on side 2. There is a minor loss of quality due to the narrower signal track. Stereo ¼ in. tape machines come in several head configurations also. The first type, 2-track, is essentially the same as the ½ track mono system except that both tracks may be recorded simultaneously giving two signal tracks in the same direction. In bioacoustics this can facilitate recording field notes. One can record clean sounds of the target organism on one track while putting a narration or voice track simultaneously on the other track.

In addition, other stereo machines come with 4 separate tracks. These ¼-track machines may record two tracks in one direction (stereo) then the tape is reversed and stereo is also available on side 2. Some machines also allow for 4 separate tracks to be recorded in the same direction in quadraphonic. This could be valuable for multiple mike recordings, but it lies outside the realm of amateur recording.

Open reel machines can record at a variety of tape speeds. Common speeds are presented in Table 1. The standard compromise between recording quality (faster speed) and tape economy is 7.5 ips or 19 centimeters per second (cms). Most moderately priced open reel units can be operated at this speed.

Cassette Recorders

PORTABLE CASSETTE TAPE RECORDERS range in price from under $100 to elaborate portable professional decks that may cost $400 or more. The cheapest cassette machines are generally not suitable for bioacoustics. These machines are primarily designed as dictating machines and are useful for taking field notes. They suffer from rather poor *frequency response* characteristics and excessive *wow* and *flutter*. They usually have a poor signal-to-noise ratio Medium priced units are available that are sufficient for many bioacoustic applications, with adequate frequency response for most uses. Such machines can be used with an auxiliary microphone and are very light and compact. The new high quality portable cassette decks offer excellent recording quality and are fairly compact. Examples of these include the Uher CR-134 and JVC CD-1635

Tape

BOTH CASSETTE AND OPEN REEL tape recorders use thin plastic tape coated with a metallic oxide that can be magnetized to store the signal. Although there are many tape manufacturers and equally as many varieties of tape, there are a few basic concepts about tape that can be used to select an appropriate kind.

The type of film used for the tape is called the backing. Most modern tape is made with a polyester plastic backing often referred to by its Dupont trade name Mylar Some recording tape is still manufactured using cellulose acetate ("acetate") backing This is weaker and more likely to break than polyester tape but because acetate tape does not stretch the break will be clean and can be mended. With Mylar tape accidental stress will cause the tape to stretch and it cannot be repaired without removing a section of the recording. The newest Mylar tapes are *tensilized* or pre-stretched so that this is not likely. Long periods of storage can result in *warping*, drying or *wrinkling* of the tape backing. These effects occur more often with acetate-backed tape

Open reel and cassette tapes come in three standard backing thicknesses (0.5, 1.0 and 1.5 mil.). Obviously the thinner tapes will allow more time on any particular size tape reel. Thin tape has several disadvantages. First, very thin tape (0.5 mil.) is more fragile and breaks or stretches easily. Thin tape often allows more *print through* than 1.0 or 1.5 mil. tape. A compromise between the convenience of more recording time per reel and the disadvantage of thin tape backing is medium thickness tape. Most workers now use 1.0 mil. tape in tensilized Mylar. This yields about 24 minutes of recording time on a standard 5 in. reel or 48 minutes on a 7 in. reel. These times are based upon the use of only one side of the tape. General procedure is to record only on side 1 because the tape can be cut and spliced for editing and there is no possibility of cross talk with another channel.

Backing is not the only difference between tapes. The oxide coating that carries the magnetic signal comes in several types. In general, the best tapes are now made with a black-oxide coating. This is usually less abrasive to the tape recorder heads than the older red-oxide coatings. Modern tapes also come in low-noise and normal. Low-noise tape is more expensive and produces cleaner recordings with a superior signal-to-noise ratio. It is especially well suited to situations where the signal has a great dynamic range. These differences are most evident with high quality recorders.

Cassette tapes come in the same three standard thicknesses and one width (⅛ in.). The coatings may be standard ferrous-oxide or chromium dioxide. Standard oxide cassettes are available with the low-noise option. Chromium dioxide coated tapes can be used only with machines designed for these tapes. Such cassette recorders usually have a switch that indicates the tape type mode as "std" or "CrO_2". When possible CrO_2 tape is preferred because of its superior quality. Cassettes come in several lengths. Small portable cassette machines often have trouble using the longer cassettes (C-90 and C-120). For field recording the C-60 is a suitable compromise. This length allows about 30 minutes recording time on one side.

Microphones

In addition to the choice of a recorder, the aspiring recordist must select a compatible microphone. As with all audio equipment the range of designs and prices is wide. Several factors are involved in choosing a mike for bioacoustics.

The first is the choice of a mike that is matched properly to the recorder. Buying an expensive professional quality microphone for use with an inexpensive cassette recorder is foolish. The microphone selected must have the same *impedance* as the input for the recorder as well as a sufficient *output level*. Be sure to check the manufacturers' specifications on the mike and recorder to assure proper matching. Proper impedance matching means choice of a mike whose impedance rating falls within the range of the recorder to be used. One should not select a 200 *ohm* mike for a recorder whose input impedance is matched for 10,000 *ohms*. If the microphone is not properly matched it may not record the signal. Even if it does, the level may be so low that it is nearly inaudible. The output level of microphones varies greatly. The best method of selecting a mike is to try it out with your tape recorder. If this is not possible, choose a mike with a medium or high output level (−57 to −53 *decibels*) (dB).

There are two basic microphone designs One, the moving coil or dynamic mike depends upon a signal being produced by a vibrating coil and a permanent magnet This type of mike does not require an auxiliary power source such as a battery The second type is called a condenser mike. Condenser mikes depend upon an electrical field that is activated by a sound modulated capacitor. This second type of microphone requires a power source The power source may be built into the tape recorder itself or involve a battery pack located in the microphone body. Many of the finest microphones use this condenser design. For most bioacoustic applications this distinction is not critical, but condenser mikes and their associated power systems require additional maintenance and service.

A third factor one should consider when buying a microphone depends upon the organism to be recorded. In most cases, the

Table 1. Tape speeds and their uses.

Tape speed		
inches/ second (ips)	centimeters/ second (cms)	use
30	76.2	professional studio quality, superior frequency response, facilitates accurate editing
15	38.1	standard semi-professional, used by some field recordists, good editing speed
7 5	19	good tape economy with good quality, used in most bioacoustic studies
3 75	9.5	excellent tape economy, compromise recording quality on all but better machines
1 5	4.7	useful for dictation, minimal quality except finest machines, used by all cassette systems
0 94 (15/16)	2.4	useful for field notes or conference recordings, poor recording quality

recordist wishes to (or must) remain a considerable distance from his subject. A directional microphone is then required. The three basic types of microphones are omnidirectional, cardiod and super or hypercardiod. Omnidirectional mikes are sensitive to sound from all directions. Omnidirectional mikes pick up "all of outdoors" including the highway behind the recordist. Cardiod mikes are more sensitive to sounds coming from in front of them and are superior for animal sound recording. The supercardiod or shotgun mikes marketed by some manufacturers are very convenient, make better recordings since they can be directed accurately at the subject, are not sensitive to background sounds even a short distance off mike (to the side), and unfortunately are very expensive The Sennheiser MK 815 hypercardiod mike retails for nearly $600. Omnidirectional or standard cardiod microphones can be made directional by mounting them in a curved dish which focuses the incoming sound. The shape of these reflectors is usually parabolic. Mikes mounted on parabolic reflectors yield results comparable to supercardiod mikes. For most investigators a parabolic reflector with a less expensive cardiod mike is the best compromise. One pre-assembled system is the Dan Gibson "sonoscope" parabolic mike (about $150).

Making Recordings

WHEN PLANNING FIELD RECORDINGS of animal sounds, several factors must be considered. One must choose a site that is convenient and accessible, yet not too severely disturbed by noise. Large highways, industrial plants and airports are the worst sources of background noise. High wind will cause microphone *dropout* with most systems.

Timing is often critical when attempting to record a particular sound. Certain calls may be uttered only when specific weather conditions exist or during one phase of the annual cycle. The presence of a recordist often has an effect on the animal's behavior, and the recordist should remain as far removed as possible within the limitations of the recording equipment. One technique, borrowed from nature photography, is to make preliminary recordings from a distance, then approach gradually. When this is done the progress should be noted on the tape. Later, in the laboratory one might be able to determine if progressive movement caused any subtle changes in the vocal performance.

Recordists have traditionally used playback of preliminary recordings or prerecorded loops to incite an organism to approach or vocalize. For many species this is an effective method of obtaining loud clean recordings. Unfortunately, the character of the vocal performance may be altered by this stimulus. It should always be mentioned in field notes when playback was used to stimulate an animal. In addition, include careful notes about the specific response made to the recording.

Glossary

Automatic level control (automatic gain control)—This is a feature which makes an automatic correction for different sound levels. It is not usually used for bioacoustics because it tends to increase the background at the expense of the signal.

Cross talk—The tendency of the signal to bleed over onto the adjacent signal track and become audible as a background noise there.

Cut—One continuous recording, from the time the recorder was engaged until it is shut off again.

Decibel (dB)—Decibels are a measure of sound intensity, a change that is perceived as twice as loud as equivalent to a change of +10 dB. The decibel scale is logarithmic, not linear.

Dropout—A blank or intermittently broken signal due to a poor connection or wind across the mike face.

Dynamic range—The range in loudness of a particular recording. A large dynamic range means that some sounds are very quiet while others are loud.

Flutter—A type of distortion due to poor speed control where the speed changes rapidly so that a constant pitch sound resembles a tremolo.

Frequency—The pitch of a sound in Hz (Hz stands for Hertz and supercedes the older measure cycles per second [cps]).

Frequency response—The frequency response is given as a range from lowest to highest in Hz. In addition to the range a figure follows such as ±2 or ±5 dB. This refers to the curve of the frequency response. The number of dB variation from a flat curve is indicated. A unit may have some sensitivity up to 15,000 Hz, but may be much less sensitive (−5 dB or more) at that frequency. One should choose a machine which meets or exceeds the actual frequency range to be recorded within the "flat" curve of the recorder and microphone.

Impedance—A measure of the resistance of some system to current. For more information on the physics of electronic impedance consult Burns and MacDonald, 1970.

Ohms—The units of resistance to an electrical current.

Output level—The specific power level of a particular unit. In the case of microphones it is measured in −dB. For example −55 dB is a higher output level than −65 dB.

Print through—The tendency for a recorded signal to magnetize the adjacent tape it is wound next to. This causes an echo effect since the signal is reproduced with a fraction of a second delay on the tape.

Signal-to-noise ratio—The ratio of the signal level (intentionally recorded sound) to the background noise. Background noise here includes both the inherent noises of the tape and mechanical or electronic noise introduced by the recorder. A high signal-to-noise ratio is desirable. Such a condition means that the background noise is relatively low and at a volume that is usually inaudible. For most recorder-mike systems a good s/n ratio is about 55 to 60 dB. Ratios lower than 50 dB are considered poor.

Tensilized—The process by which polyester (Mylar) tape is pre-stretched so that further stretching is unlikely. Tensilized tape is desirable because the tape is more likely to make a clean break that can be repaired.

Warping—The tendency for old tape to change shape and become twisted slightly from one side then the other. Warped tape will not run smoothly across the tape heads and will not record or playback properly.

Wrinkling—This aging effect is similar to warping but only involves the edges of the tape so that a fringe of crinkles appear on the tape with the same sort of unsatisfactory results as warped tape.

Wow—A type of distortion caused by incorrect tape speed control. This is similar to flutter except that the pitch changes are slower so that a wow sound is heard.

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