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ECHOLOCATION OVERVIEW

When a sound is produced, additional sounds are produced at higher frequencies. The sound with the lowest frequency is the fundamental harmonic. As a by-product of sound production, other harmonics are produced at higher frequencies. For example, if sound is produced at 20 kHz then harmonics will be produced at 40, 60, etc. In addition to increasing frequencies, harmonics are produced at increasingly lower amplitudes (energy). Because the loss of energy in a sound due to attenuation increases as the frequency increases, these higher harmonics do not travel as far from the source.

Bats produce sounds that fall into two categories: vocalization and echolocation. Vocalizations are sounds used in social communication or distress conditions. Echolocation is used to orient between roosting and foraging areas, to find and capture prey, and, in some species, for social communication. For clarity and consistency, a pulse will refer to a single sound emitted by an individual and a call or call sequence will refer to a continuous series of pulses from a single individual.

Roost/distress/social communication calls are produced in either the ultrasonic or audible sound ranges or both. These calls are produced as a bat is leaving a roost, when in distress (handling), or as they fly with conspecifics. They serve to orient a bat in the initial stages of flight. This call type is quickly changed to search phase pulses once the bat leaves the immediate area of the roost or is no longer in distress. These calls may also serve some function in social communication at the roost site. (Figure 1).

The echolocation calls of most bats are produced in the ultrasonic range (above 20 kHz). Echolocation calls are commonly classified into three types:

1. Search phase pulses. These pulses are produced as a bat searches for prey. The structure, frequency range, and the time between successive pulses are all relatively consistent within the same habitat type. The general structure of the search phase call depends on the size, wing morphology, species, and foraging habitat of the bat. Examples of search phase pulses of 10 species of bats in the eastern United States are illustrated in Appendix B. Search phase calls are used in the

acoustic identification of some species because they are commonly produced and are consistent in structure.

2. Approach phase. These pulses develop from search phase pulses as a potential prey item is detected. The frequency range increases initially then decreases as it passes through the approach phase sequence. This increase in frequency range allows for the gaining of additional detail on the possible prey item. In addition, the duration of each pulse and the time between pulses decreases. This is a result of the bat getting closer to the prey item.
3. Terminal phase/feeding buzz pulses. These pulses are produced as a bat closes in and attempts to capture a potential prey item. The pulses continue to decrease in frequency range and duration throughout the approach phase call sequence until the prey item is captured (feeding buzz). Once the prey is captured and eaten, the bat will start searching for the next prey item by producing search phase pulses (Figure 2).

The structure of the echolocation pulses has been classified into two major groups. The first group is an echolocation pulse that is comprised of only a constant frequency (CF) component. The other group contains pulses that continually change in frequency over time (Frequency modulated (FM)). The utility of these two call structures is described below.

1. FM pulses. These pulses cover a wide frequency range and are short in duration. FM pulses provide detailed information (location of clutter; size, speed, and direction of prey items) about the bat's surroundings. However, the range of detection for a bat using FM calls is quite limited. This type of pulse structure is commonly used by bats that forage in cluttered or semi-cluttered environments.
2. CF pulses. These pulses are produced at a constant frequency and are longer in duration than FM pulses. They provide the ability to detect items in the flight path of the bat, but generally provide less detailed information than FM calls. However they do have the advantage of

having an increased detection distance over FM pulses. Because these calls are at a constant frequency, the returning echo bounces off the fluttering wings of an insect in a manner that alters the frequency of the echo throughout the duration of the call. This altered echo is referred to as a "glint", and is useful for identifying insects. Most bats that use CF calls forage in open areas. However, some bats that use CF pulses forage in cluttered environments. These species have special adaptations that allow for the separation of background clutter and prey items. Because CF calls provide very limited information on the range and direction of the prey item, a bat that uses CF calls in open habitats will alter its' echolocation call to include a larger FM component when a prey item is detected.

FM and CF search phase calls are not exclusive groups, but rather are the extremes of a continuum of search phase call types. Species use search phase sequences with various proportions of both call types. The FM and CF components of individuals calls within a sequence may also vary in response to habitat type (cluttered vs. uncluttered) or prey detection.

In most bats of the eastern United States, species identity can only be determined by examining FM calls, because only with FM calls is there the sufficient structure present that allows for species differences to be identified.

With the wide variety of echolocation calls used by bats, a researcher can utilize the different call types to gather specific information on the behavior of bats. The detection of roost/distress calls under natural recording conditions may alert the researcher to the presence of a previously unknown roost site. Monitoring search phase and terminal phase calls allow for specific information to be gained about a bat's activity in an area. Search phase calls allow for the identification of the species of bats present in an area. In addition, they allow for the determination of areas in which bats are foraging. Thus, the determination of species' presence, habitat relationships, and activity patterns of individual species can be examined. Approach and terminal phase calls are useful in documenting successful foraging in an area rather than just searching for prey items.

Figure 1. Example of Roost/distress call sequence.

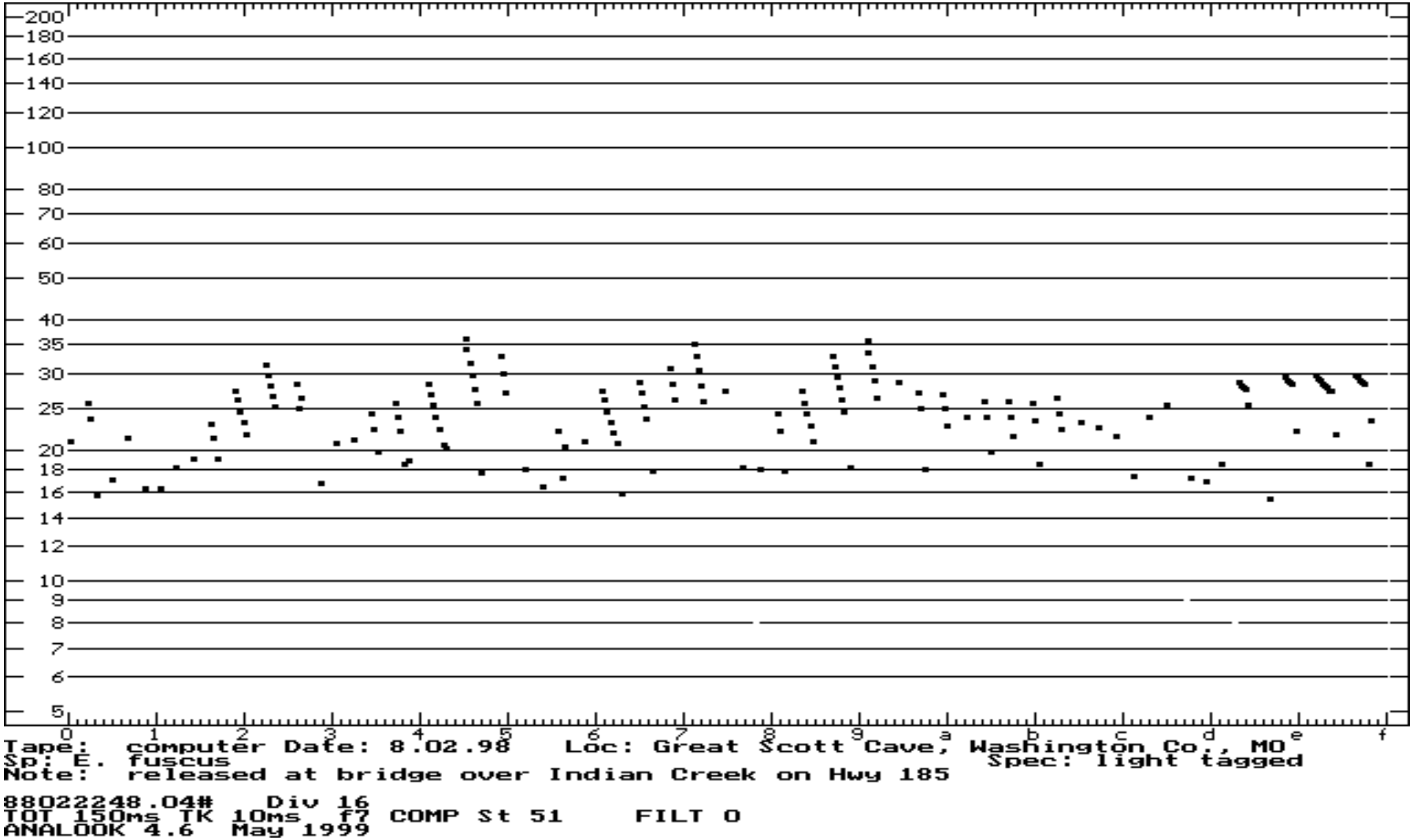
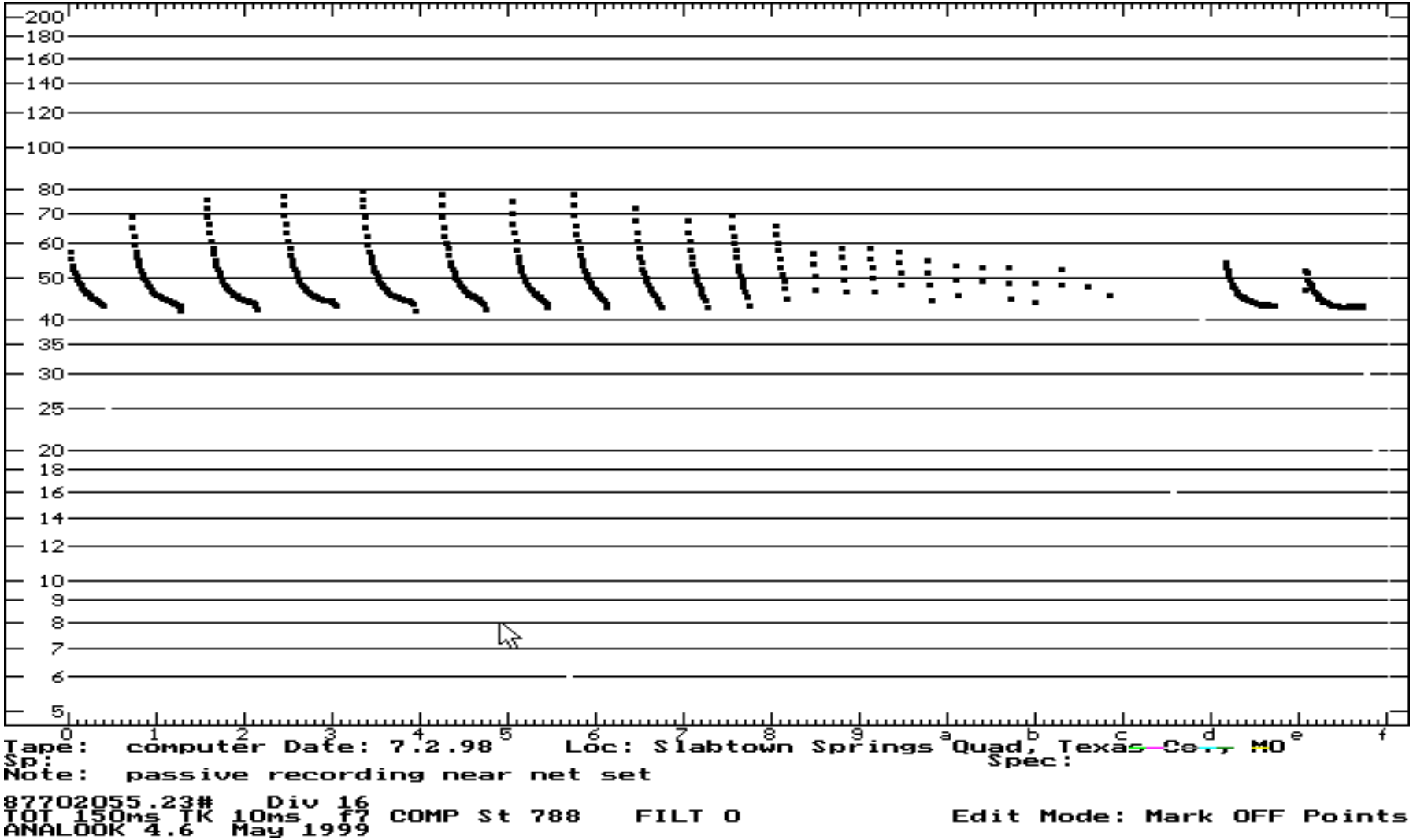


Figure 2. Example of Feeding Buzz.



SELECTED REFERENCES

Studies Utilizing The Anabat System Are Indicated In Bold

Ahlen, I. 1981. Identification of Scandinavian Bats by Their Sounds. Report number 6, the Swedish University of Agricultural Sciences, Department of Wildlife Ecology; Uppsala.

Ahlen, I. 1990. Identification of bats in flight. Swedish Society for Conservation of Nature, Stockholm, No. 0312.

Barclay, R.M.R. 1983. Echolocation calls of emballonurid bats from Panama. Journal of Comparative Physiology A. Sensory, Neural, and Behavioral Physiology, 151:515-520.

Barclay, R.M.R. 1985. Long- versus short-range foraging strategies of hoary (Lasiurus cinereus) and silver-haired (*Lasionycteris noctivagans*) bats and the consequences for prey selection. Canadian Journal of Zoology, 63:2507-2515.

Barclay, R.M.R. 1986. The echolocation calls of hoary (*Lasiurus cinereus*) and silver-haired (*Lasionycteris noctivagans*) bats as adaptations for long- versus short-range foraging strategies and the consequences for prey selection. Canadian Journal of Zoology 64:2700-2705.

Barclay, R.M.R. 1999. Bats are not birds: a cautionary note on using echolocation calls to identify bats. Journal of Mammalogy, 80:290-296.

Barclay, R.M.R., J.H. Fullard, and D.S. Jacobs. 1999. Variation in the echolocation calls of the hoary bat (*Lasiurus cinereus*): influence of body size, habitat structure, and geographic location. Canadian Journal of Zoology 77:530-534.

Bell, G.P. 1980. Habitat use and response to patches of prey by desert insectivorous bats. Canadian Journal of Zoology, 58:1876-1883.

Bellwood, J.J. and J.H. Fullard. 1984. Echolocation and foraging behavior in the Hawaiian hoary bat, *Lasiurus cinereus semotus*. Canadian Journal of Zoology 62:2113-2120.

Betts, B.J. 1998. Effect of interindividual variation in echolocation calls on identification of big brown and silver-haired bats. Journal of Wildlife Management 62:1003-1010.

Brigham, R.M., J.E. Cebek, and M.B.C. Hickey. 1989. Intraspecific variation in the echolocation calls of two species of insectivorous bats. Journal of Mammalogy 70:426-428.

Bogdanowicz, W. 1990. Geographic variation and taxonomy of Daubenton's bat, *Myotis daubentoni*, in Europe. Journal of Mammalogy 71:205-218.

Britzke, E.R., K.L. Murray, B.M. Hadley, and L.W. Robbins. 1999. Measuring bat activity with the Anabat II bat detector system. Bat Research News, 40:1-3.

Buchler, E.R. 1976. A chemiluminescent tag for tracking bats and other small nocturnal animals. Journal of Mammalogy 57:173-176.

Buchler, E.R. 1980. The development of flight, foraging, and echolocation in the little brown bat (*Myotis lucifugus*). Behavioral Ecology and Sociobiology 6:211-218.

Caddle, C. and L. Lumsden. 1997. Some hints on how to use the new Analook. The Australian Bat Society Newsletter, 8:18-20.

Conole, L.E. and G.A. Baverstock. 1995. Bats in remnant vegetation along the Barwon River, south-west Victoria: a survey by electronic bat-detector. The Victorian Naturalist, 112:208-211.

Crampton, L.H. and R.M.R. Barclay. 1996. Habitat selection by bats in fragmented and unfragmented aspen mixedwood stands of different ages. Pp. 238-259 *in* Bats and Forest Symposium (R.M.R. Barclay and R.M. Brigham, eds.). British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

Crampton, L.H. and R.M.R. Barclay. 1998. Selection of roosting and foraging habitat by bats in different-aged aspen mixedwood stands. Conservation Biology, 12:1347-1358.

Crome, F.H.J. and G.C. Richards. Bats and gaps: Microchiropteran community structure in a Queensland rain forest. Ecology, 69:1960-1969.

Erickson, J.L. and S. D. West. 1996. Managed forest in the Western Cascades: the effects of seral stage on bat habitat use patterns. Pp. 215-227 *in* Bats and Forest Symposium (R.M.R. Barclay and R.M. Brigham, eds.). British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

Fenton, M.B. 1982. Echolocation calls and patterns of hunting and habitat use of bats (Microchiroptera) from Chillagoe, North Queensland. Australian Journal of Zoology, 30:417-425.

Fenton, M.B. 1994. Assessing signal variability and reliability: 'to thine ownself be true.' Animal Behaviour 47: 757-764.

Fenton, M.B. and G.P. Bell. 1981. Recognition of species of insectivorous bats by their echolocation calls. Journal of Mammalogy, 62:233-243.

Fenton, M.B. and G.K. Morris. 1976. Opportunistic feeding by desert bats, *Myotis spp*. Canadian Journal of Zoology, 54:526-530.

Fenton, M.B., H.G. Merriam, and G.L. Holroyd. 1983. Bats of Kootenay, Glacier, and Mount Revelstoke national parks in Canada: identification by echolocation calls, distribution, and biology. Canadian Journal of Zoology, 61:2503-2508.

Griffin, D.R., F.A. Webster, and C.R. Michael. 1960. The echolocation of flying insects by bats. Animal Behaviour 8:141-154.

Griffin, D.R. 1971. The importance of atmospheric attenuation for the echolocation of bats (Chiroptera). Animal Behaviour 19:55-61.

Grindal, S.D. and R.M. Brigham. 1999. Impacts of forest harvesting on habitat use by foraging insectivorous bats at different spatial scale. Ecoscience, 6:25-34.

Grindal, S.D. and R.M. Brigham. 1998. Short-term effects of small-scale habitat disturbance on activity by insectivorous bats. Journal of Wildlife Management, 62:996-1003.

Hayes, J.P. 1997. Temporal Variation in activity of bats and the design of echolocation studies. Journal of Mammalogy, 78:514-524.

Hayes, J.P. and M.D. Adam. 1996. The influence of logging Riparian Areas on habitat utilization by bats in Western Oregon. Pp. 228-292 *in* Bats and Forest Symposium (R.M.R. Barclay and R.M. Brigham, eds.). British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

Heller, K-G. and O.V. Helversen. 1989. Resource partitioning of sonar frequency bands in rhinolophoid bats. Oceologia 80:178-186.

Herr, A., N.L. Klomp, and J.S. Atkinson. 1997. Identification of bat echolocation calls using a decision tree classification system. Complexity International (Online publication), 4:1-11.

Hovorka, M.D., C.S. Marks, and E. Muller. 1996. An improved chemiluminescent tag for bats. Wildlife Society Bulletin, 24:709-712.

Jacobs, D.S. 1999. Intraspecific variation in wingspan and echolocation call flexibility might explain the use of different habitats by the insectivorous bat, *Miniopterus schreibersii* (Vespertilionidae: Miniopterinae). Acta Chiropterologica 1:93-103.

Jensen, M.E. and L.A. Miller. 1999. Echolocation signals of the bat *Eptesicus serotinus* recorded using a vertical microphone array: effect of flight altitude on searching signals. Behavioral Ecology and Sociobiology 47:60-69.

Jones, G. and T. Kokurewicz. 1994. Sex and age variation in echolocation calls and flight morphology of Daubenton's bats *Myotis daubentonii*. Mammalia 58:41-50.

Jones, G. and R.D. Ransome. 1993. Echolocation calls of bats are influenced by maternal effects and change over a lifetime. Proceedings of the Royal Society of London B 252:125-128.

Jones, G. and S.M. van Parijs. 1993. Bimodal echolocation in pipistrelle bats: are cryptic species present? Proceedings of the Royal Society of London B 251:119-125.

Jones, G., T. Gordon and J. Nightingale. 1992. Sex and age differences in the echolocation calls of the lesser horseshoe bat, *Rhinolophus hipposideros*. Mammalia 56:189-193.

Jones, G., K. Sripathi, D.A. Waters, and G. Marimuthu. 1994. Individual variation in the echolocation calls of three sympatric Indian Hipposiderid bats, and an experimental attempt to jam bat echolocation. Folia Zoologica 43:347-362.

Kalko, E.K.V. 1995. Insect pursuit, prey capture and echolocation in pipistrelle bats (Microchiroptera). Animal Behaviour 50:861-880.

Kalko, E.K.V. and H.U. Schnitzler. 1989. The echolocation and hunting behavior of Daubenton's bat, *Myotis daubentoni*. Behavioral Ecology and Sociobiology 24:225-238.

Kalko, E.K.V. and H.U. Schnitzler. 1993. Plasticity in echolocation signals of European pipistrelle bats in search flight: implications for habitat use and prey detection. Behavioral Ecology and Sociobiology 33:415-428.

Krusic, R.A. and C.D. Neefus. 1996. Habitat associations of bat species in the White Mountain National Forest. Pp. 185-198 *in* Bats and Forest Symposium (R.M.R. Barclay and R.M. Brigham, eds.). British Columbia Ministry of Forests, Victoria, British Columbia, Canada.

Kuenzi, A.J. and M.L. Morrison. 1998. Detection of bats by mist-nets and ultrasonic sensors. Wildlife Society Bulletin, 26:307-311.

Law, B.S., J. Anderson, and M. Chidel. 1998. A bat survey in State Forests on the south-west slopes region of New South Wales with suggestions of improvements for future surveys. Australian Zoologist, 30:467-479.

Law, B.S., J. Anderson, and M. Chidel. 1999. Bat communities in a fragmented landscape on the south-west slopes of New South Wales, Australia. Biological Conservation, 88:333-345.

Lawrence, B.D. and J.A. Simmons. 1982. Measurements of atmospheric attenuation at ultrasonic frequencies and the significance for echolocation by bats. Journal of the Acoustical Society of America 71:585-590.

MacDonald, K., E. Matsui, R. Stevens, and M.B. Fenton. 1994. Echolocation calls and field identification of the eastern pipistrelle (*Pipistrellus subflavus*: Chiroptera: Vespertilionidae), using ultrasonic bat detectors. Journal of Mammalogy 75:462-465.

Masters, W.M., K.A.S. Raver, and K.A. Kazial. 1995. Sonar signals of big brown bats, *Eptesicus fuscus*, contain information about individual identity, age and family affiliation. Animal Behaviour 50:1243-1260.

Miller, L.A. and H.J. Degn. 1981. The acoustic behavior of four species of Vespertilionid bats studied in the field. Journal of Comparative Physiology 142:67-74.

Moss, C.F., D. Reddish, C. Gounden, and T.H. Kunz. 1997. Ontogeny of vocal signals in the little brown bat, *Myotis lucifugus*. Animal Behaviour 54:131-141.

Mills, D.J., T.W. Norton, H.E. Parnaby, R.B. Cunningham, and H.A. Nix. 1996. Designing surveys for microchiropteran bats in complex forest landscapes – a pilot study from southeast Australia. Forest Ecology and Management, 85:149-161.

Murray, K.L., E.R. Britzke, B.M. Hadley, and L.W. Robbins. 1999. Surveying bat communities: a comparison between mist nets and the Anabat II bat detector system. Acta Chiropterologica, 1:105-112.

Neuweiler, G. 1989. Foraging ecology and audition in echolocating bats. Trends in Ecology and Evolution, 4:160-166.

Obrist, M.K. 1995. Flexible bat echolocation: the influence of individual, habitat, and conspecifics on sonar design. Behavioral Ecology and Sociobiology, 36:207-219.

O'Farrell, M.J. 1999. Blind test for ability to discriminate vocal signatures of the little brown bat *Myotis lucifugus* and the Indiana bat *Myotis sodalis*. Bat Research News, 40:44-48.

O'Farrell, M.J. and W.L. Gannon. 1999. A comparison of acoustic versus capture techniques for the inventory of bats. Journal of Mammalogy, 80:24-30.

O'Farrell, M.J., B.W. Miller, and W.L. Gannon. 1999. Qualitative identification of free-flying bats using the Anabat detector. Journal of Mammalogy, 80:11-23.

de Oliveira, M.C. 1998. Towards standardized descriptions of the echolocation calls of microchiropteran bats: pulse design terminology for seventeen species from Queensland. Australian Zoologist 30: 405-411.

Parsons, S. 1997. Search-phase echolocation calls of the New Zealand short-tailed bat (*Mystacina tuberculata*) and long-tailed bat (*Chalinolobus tuberculatus*). Canadian Journal of Zoology 75: 1487-1494.

Parsons, S., C.W. Thorpe, and S.M. Dawson. Echolocation calls of the long-tailed bat: a quantitative analysis of types of calls. Journal of Mammalogy 78:964-976.

Pearl, D.L. and M.B. Fenton. 1996. Can echolocation calls provide information about group identity in the little brown bat (*Myotis lucifugus*)? Canadian Journal of Zoology 74:2184-2192.

Pye, J.D. 1980. Echolocation signals and echoes in air. Pp. 309-353 in Animal sonar systems (R-G. Busnell, and J.F. Fish, eds.). Plenum Press, New York.

Pye, J.D. 1993. Is fidelity futile? The 'true' signal is illusory, especially with ultrasound. Bioacoustics 4:271-286.

Robbins, L.W. and E.R. Britzke. 1999. Discriminating *Myotis sodalis* from *M. lucifugus* with Anabat – a critique. Bat research News, 40:75-76.

Rydell, J. 1990. Behavioural variation in echolocation pulses of the northern bat, *Eptesicus nilssoni*. Ethology 85:103-113.

Rydell, J. 1993. Variation in the sonar of an aerial-hawking bat (*Eptesicus nilssoni*). Ethology 93:275-284.

Simmons, J.A., M.B. Fenton, and M.J. O'Farrell. 1979. Echolocation and pursuit of prey by bats. Science, 203:16-21.

Schumm, A., D. Krull, and G. Neuweiler. 1991. Echolocation in the notch-eared bat, *Myotis emarginatus*. Behavioral Ecology and Sociobiology 28:255-261.

Thomas, D.W. 1988. The distribution of bats in different ages of Douglas-fir forests. Journal of Wildlife Management, 52:619-626.

Thomas, D.W., G.P. Bell, and M.B. Fenton. 1987. Variation in the echolocation call frequencies recorded from North American vespertilionid bats: a cautionary note. Journal of Mammalogy 68:842-847.

Vaughan, N., G. Jones, and S. Harris. 1997. Identification of British bats species by multivariate analysis of echolocation call parameters. Bioacoustics, 7:189-207.

Vaughan, N., G. Jones, and S. Harris. 1997. Habitat use by bats (Chiroptera) assessed by means of a broad-band acoustic method. Journal of Applied Ecology, 34: 716-730.

Von Frenckell, B. and R.M.R. Barclay. 1987. Bat activity over calm and turbulent water. Canadian Journal of Zoology, 65:219-222.

Woodside, D.P. and K.J. Taylor. 1985. Echolocation calls of fourteen bats from eastern New South Wales. Australian Mammalogy, 8:279-297.

ULTRASONIC DETECTORS

BACKGROUND

In the last thirty years, ultrasonic detectors have been increasingly used in the study of bat echolocation and behavior. Detectors possess either a narrow-band or a broadband microphone. Narrow-band microphones detect sound in a very small frequency range (~3-5 kHz), whereas broadband microphones detect sound over a wide range of frequencies (~20-200 kHz). The two types of bat detectors are suited for different studies. A bat detector with a narrow-band microphone is useful when studying a single species or a small group of species whose echolocation calls utilize a specific frequency. Alternatively, a bat detector with a broadband microphone permits the study of the echolocation calls of most members of the bat community simultaneously.

THE ANABAT SYSTEM

The Anabat bat detector system has been extensively used by bat researchers. It has several advantages over other systems. It utilizes a broadband microphone and has the ability to save echolocation calls directly to a computer. This permits for the real-time display and analysis of echolocation calls. With Anabat files being saved to a computer, the transfer of files between computers as well as between and among researchers is enabled. recording and analysis software written specifically for the system. The system is relatively inexpensive to obtain, and requires only small maintenance expenses (i.e. batteries). Finally, the system is easy to learn, operate, and set up in the field.

The Anabat system also has some disadvantages. The Anabat system only utilizes the harmonic that contains the most energy (most of the time, but not always this is the fundamental harmonic). By selecting only the harmonic with the most energy for analysis, the information on the other harmonics is lost. In addition, the Anabat system also removes all amplitude information from the echolocation call. This eliminates the analysis of power-spectral analysis for the determination of such parameters as frequency of maximum energy. This loss of detailed information may limit the ability of the Anabat system to effectively investigate other questions concerning echolocation; however, the Anabat system is designed to examine the possibility of acoustic identification of species.

The Anabat system has been used to:

1. locate sites with high bat activity for subsequent mist netting,
2. examine habitat use,
3. acoustic identification of bats once a library of known calls has been recorded, and
4. compare capture techniques with acoustical methods.

ANABAT SYSTEM COMPONENTS

1. The Anabat II bat detector (required)
2. The Zero Crossing Analysis Interface Module (ZCAIM) (required)
3. Delay switch (useful if recording to a tape recorder)
4. Universal Timer (not very useful, but can be if recording to a tape)
5. Recording devices (one of these is required)
   a. Computer
   b. Tape recorder
6. Computer software (necessary)
   a. Anabat
   b. Analook

1. The Anabat II bat detector

As stated previously, the Anabat II bat detector contains a broadband microphone, which detects sounds ranging from 20 to 200 kilohertz (kHz). When a sound within this range is detected, information on the call is sent to either a computer (when connected to a ZCAIM) or an audio tape recorder. The bat detector also produces an audible representation of the echolocation call (see B. below). The detector is powered by a single 9-volt battery.

There are several controls present on the bat detector.

A. The power/volume knob. This knob turns the power on and off. Once on, it also serves to adjust the volume of the audible output from a detected echolocation call. The volume level alters the speaker output, but does not change the effectiveness of the unit in detecting and recording echolocation calls.

B. The division ratio knob. This knob is used to select the reduction value of the detected echolocation calls in order to obtain an audible representation. The incoming frequencies of an echolocation call will be divided by the selected number. (Ex. If the setting on this knob is 16 then a sound produced by a bat at 48 kHz (not detected by human hearing) will be reduced and played through the speaker at 3 kHz (detected by human hearing). <u>It is extremely important that the value selected on the bat detector be the same value as that assigned for the division ratio in the Anabat program. If these two values are different, the data collected are meaningless.</u> For most bats in the eastern US, the best setting for the division ratio is 16.

C. The sensitivity knob. The sensitivity of the bat detector determines strength needed for an incoming call to be detected. When the sensitivity is lowered, a stronger signal is necessary in order to be detected. This translates into a smaller detection area because the source of the signal has to be closer to the microphone to be received. This detection area varies for each species of bat. Some bats (i.e. *Eptescius, Lasiurus*) have high intensity echolocation calls. This allows them to be detected at a greater distance from the detector than those species with a low intensity echolocation call (i.e. big-eared *Myotis, Corynorhinus*). When the sensitivity is increased, the area sampled as well as the ability to detect quiet echolocation calls will increase. The sensitivity of the detector should be set at a level that is just below the threshold of extraneous noise (i.e. insect noises, echoes over water), but as high as possible to allow sampling as many echolocation calls as possible.

D. The calibration button. When pushed, this button produces a sound at a specified and constant frequency for the duration of time the button is depressed. This allows for the testing of the setup and function of the equipment. The calibration button can also be used to save files when in Record mode (see page 25).

E. Low battery indicator. This light illuminates when the bat detector's battery is low. However, when this light is initially illuminated, enough battery life remains to detect echolocation calls for several more hours.

F. Microphone button. When depressed, this button allows for the addition of vocal notes to be made on the audiotape if one is being used to record the echolocation calls.

G. Tape switch. When pushed up, this switch allows the bat detector to record directly to a tape player. If recording directly to a computer, this switch should be in the down position.

H. Speaker. The speaker broadcasts the audible sounds from an echolocation call after it has been translated into a frequency range that is audible to the human ear. (See B. above).

I. Timer on/off switch. This switch allows the bat detector to work with the universal timer (see page 7). When on, this option allows the timer to control recording done by the bat detector.

J. Recorder/Timer jack. This jack accepts the cable that attaches the bat detector to the ZCAIM, a tape recorder, or a universal timer.

K. Headphone jack. This jack allows for a set of headphones to be plugged into the bat detector so that the audible output is played in the headphones instead of over the detector's internal speaker.

L. 12 volt jack. This jack allows for the attachment of a 12-volt cable. This permits the bat detector to be powered by an external power supply.

M. HF output. This jack allows for the high fidelity output to be recorded to an external recorder.

2. <u>The Zero Crossing Analysis Interface Module</u>

The Zero Crossing Analysis Interface Module (ZCAIM) takes the sound detected by the bat detector and changes this into an analog format. This format can then be interpreted by the Anabat program into frequency time representation of the detected

echolocation calls. Sound waves are produced as sine waves. Zero Crossing Analysis counts the number of times the sine wave crosses zero (zero crossing) and translates this into the frequency of the call. The more times the sine wave passes zero, the higher the frequency of the call. The echolocation call sequence can either come directly from the bat detector or from a playback of an audiotape of previously recorded echolocation calls. The ZCAIM is powered by 4 AA batteries. Controls present on the ZCAIM include:

A. Sensitivity knob. This knob represents the level of input coming into the ZCAIM required to trigger the interface. <u>In order to properly detect echolocation calls and send them to a computer, the sensitivity must be set at a minimum of 10.</u>
B. Input jack. This jack accepts the cable from either the bat detector (when recording directly to a computer) or from a tape player (when calls were saved to an audiotape).
C. Sensitivity indicator. This light illuminates as the ZCAIM detects echolocation calls being input.
D. Low battery indicator. This light illuminates as the batteries are getting low. The light is an early indicator and like the bat detector, the ZCAIM will continue to function properly for a limited amount of time after the light is first illuminated.
E. Parallel port. This port is the attachment for the parallel cable that connects the ZCAIM to the computer
F. 6 Volt jack. This jack allows for the ZCAIM to be powered by an external power source instead of the internal batteries.

3. <u>The Delay Switch</u>

The delay switch is a unit that can be used when recording the output of the bat detector to audiotape. This switch momentarily stores the information from an incoming call, until the tape recorder is activated and the tape is moving at full speed. The echolocation call is then sent to the tape for recording. After the echolocation calls are recorded, the delay switch adds the time of the echolocation call as well as a calibration tone to the audiotape.

A. ON/OFF switch. This switch turns on the delay switch. It can also be turned to the N/S position which automatically turns the delay switch on when the ambient light falls below a certain level (the onset of darkness) and off as the ambient light increases (sunrise).
B. ON light. This light illuminates when the ON/OFF switch is in the on position, and indicates the delay switch is fully activated.
C. N/S light. This light illuminates when the on/off switch is in the n/s mode, and indicates the unit will automatically turn off when the ambient light drops.
D. Data light. This light illuminates when there are echolocation calls being detected by the bat detector.
E. Calibration light. This light is illuminated as the calibration tone is added to the recorded echolocation call. At the end of the echolocation call, a calibration tone is added on the audiotape in order to mark the end of the call.
F. Time light. This light illuminates when the time the echolocation call is received is placed on the audiotape after the calibration tone.
G. Time screen. This screen shows the time of day. This time is added to the audiotape after the calibration tone. This allows for the time of each sequence to be recorded for later activity analysis.
H. Mode button. Adjusts the internal clock of the delay switch and thus the information placed on the tape after the calibration tone.
I. Adjust button. This button adjusts the values on the time screen to set the correct time.
J. Humidity/Temperature connector. This jack accepts a cable to connect a humidity and temperature-monitoring device to the delay switch. This way information on the temperature and humidity can be obtained for the period of time echolocation calls are monitored.
K. Timer jack. This jack allows for the universal timer to be attached to the delay switch. When connected, the timer controls the time

intervals in which the delay switch is operational (and thus when echolocation calls can be recorded).

L. Bat detector connection. This jack allows for the connection of the bat detector to the delay switch. Information from the bat detector is passed through the delay switch and on to the tape recorder when the recorder is operational.

M. 12 volt jack. This jack allows for the connection of an external 12-volt power supply. This power supply recharges the internal battery. Once fully charged, the delay switch will operate off the internal battery for the entire night.

4. <u>The Universal Timer</u>

The universal timer controls the recording of echolocation calls. This timer has an option that allows for the initiation of recording of echolocation calls when darkness arrives (as determined by the amount of ambient light present). Also, the recording of echolocation calls can be recorded for discrete periods of time. The unit can be turned on to record for a specified time interval and a separate knob controls the amount of time between sampling intervals. The timer is powered by a 9-volt battery inside the unit. The controls on the universal timer include:

A. ON/Off switch. This switch turns the power to the timer on and off. The timer can also be set to automatically turn on when the ambient light levels drop below a predetermined level. This allows the Anabat systems to be set up during daylight hours, while conserving the battery until needed for the recording of echolocation calls. When on, the timer has the power to control the recording of echolocation calls.

B. On time knob. This knob is used to set the amount of time the universal timer is “on” in each sampling period. During the “on” time, the Anabat system records the echolocation calls detected by the bat detector. Thus, the selection of this knob controls the length of each sampling period.

C. Off time knob. This knob is used to select the amount of time between sampling periods. During the "off" time, the bat detector will still detect echolocation calls but they will not be saved to a tape recorder or laptop computer.

D. Bat detector/delay switch connector. This jack allows for the attachment of the bat detector, delay switch and timer system. When all are attached, the timer controls the periods of time when the echolocation calls are recorded through the delay switch and attached tape recorder.

5. Recording devices

There are two devices that can be used to store detected echolocation calls: laptop computers and tape recorders. The bat detector can be attached to a laptop computer through the ZCAIM. This allows for the echolocation calls to be saved directly to the hard drive of the computer. A tape recorder can also be used to record echolocation calls directly from the bat detector. For analysis, the tape must be played through the ZCAIM to save the call sequences on the hard drive of the computer.

When saving to an audiotape there are several concerns that need to be addressed. First is the fact that as the batteries drain, the tape speed slows. By changing the speed of the tape, the structure of the recorded echolocation calls is distorted. This possible distortion is not only present when the calls are recorded but also when the tape is played through the ZCAIM to obtain computer files. In addition, the number of files saved on the computer varies with each playback of the tape. Also, when a tape is played into the computer, the resulting files have large amounts of extraneous noise. This increases the time required for the analysis of echolocation calls and decreases the number of calls within each sequence that can be used.

Saving echolocation calls directly to a laptop computer is advantageous because it allows one to view and quickly analyze echolocation calls. It also removes the additional step of playing a tape through the ZCAIM to obtain computer files of the tape-recorded echolocation calls. Also, the cost of laptops that are able to run the Anabat and Analook

software are now relatively inexpensive. However, the computer does have some disadvantages. Because of the limited internal battery life, it is necessary to purchase equipment to enable the computer to run off an external battery source (car battery). These can be cumbersome to carry especially if there is much hiking into a recording area. Also, the presence of a computer makes the setup potentially more visible and thus more open to theft. Care must be taken to place these units in a protected area.

6. Computer software

There are two computer programs that are included with the Anabat system.

A. The Anabat program is used to record echolocation calls to an Anabat file format when saved on a computer. Anabat takes information on echolocation calls from the ZCAIM and constructs a visual display of the time (X-axis) and frequency (Y-axis) components of the echolocation call. The section on the use of Anabat starts on page 22.

B. The Analook program is used in the analysis of previously saved echolocation call sequences. Analook loads Anabat files that are displayed on an X Y graph with one alteration. The frequency axis on the Analook screen is on a log scale. This allows for better representation of the structure of the echolocation calls. Analook allows for the cleaning and editing of echolocation call sequences in order to remove fragmentary calls and extraneous noise. From these cleaned echolocation call sequences, Analook can be used to obtain numerical values for different parameters that describe the structure of the echolocation call. The section of the use of Analook starts on page 34.

ANABAT

DISPLAY

The Anabat program is initiated by typing Anabat6 at the directory prompt where the recorded Anabat files are to be saved. This will open the introductory screen which shows the version of the program, when it was written, and the author of the program (Chris Corben). To continue past this screen push any key.

The main screen is now displayed. The bulk of the screen is made up of a graph. The X-axis represents a time scale, and frequency is displayed on the Y-axis. There are several subheadings or values along the top margin of this graph, from left to right as follows:

Realtime/Compressed. When in real time, the echolocation call sequence is represented as it is actually detected. Compressed time reduces the time interval between echolocation calls so that more calls are shown on the screen at one time. The **spacebar** is used to toggle between options.

kHz. Denotes the frequency range represented on the Y-axis.

DIV. Denotes the division ratio as set in the Anabat Configuration menu. Remember that this value needs to be set to the same value as the value on the bat detector to obtain meaningful results.

Cal. Denotes the frequency value of the calibration tone. When the tone calibration button is pushed on the bat detector, then this value will be represented by a continuous tone on the Anabat program at the frequency selected in the configuration menu (see below).

TOTAL. Denotes the total amount of time represented on the complete X axis.

TICKS. Denotes the amount of time represented by each major tick mark on the X axis.

Npts. Denotes the number of data points shown on the current display screen

Buff. This value represents the percentage of the total maximum data points available in a file that are actually contained in the loaded file.

F(). Denotes the function key that was depressed in order to obtain the display with the current time scale.

RECORDING MODES

The Anabat program allows for echolocation calls to be saved through two modes. Both of these recording modes are initiated from the main Anabat screen.

Record mode is initiated by hitting the **SHIFT – N** keys. This mode allows for the detection of incoming echolocation calls, but only saves after receiving a prompt from the user. The sequence can be saved by pressing the S key, or by hitting the calibration button (only when this option is activated in the Main menu, see below).

Monitor mode is initiated by hitting the **CONTROL – N** keys. This mode allows for the detection and automatic recording of echolocation calls. This negates the need for a researcher to be present for the recording of echolocation call sequences. The criteria used to save sequences are listed below under the Autosave menu.

To exit either recording mode, just hit the **spacebar**. This brings you back to the main Anabat screen.

All saved Anabat files have the same convention used in the naming of the file. The date and time (taken from the internal clock of the computer) are included in the filename and file extension. For this reason it is important to check and make sure that the internal time and date of the computer is correct. An example of the naming of an Anabat file is as follows:

85132001.59#

For the filename:

The first position in the filename is the last digit of the year, 0-9.

The second digit in the filename represents the month of the year. The number of the month is used until October when an A is used, Nov. = B, Dec. = C.

The third and fourth digits represent the day of the month.

The fifth, sixth, seventh, and eight digits represent the time (in military time) that the file name was saved.

For the file extension:

The first and second digits represent the number of seconds in the in the minute that the file was saved.

The third digit is always a #. This identifies the file as an Anabat file.

The example filename above was recorded at 8:59 PM on 13 May 1998.

TEXT HEADERS

Text headers are sections included with each Anabat file that allow recording specific information relative to that particular file. This information might include species identity, site location, capture notes, weather conditions, etc. To record a current text header to each file, the new data must be entered into the default header. To insert this information, depress the **T** key while at the main Anabat screen. This brings up the Insert text screen. Enter the correct information in each location. To move between fields in the form depress the **TAB** key. Once everything is filled out correctly, this information can be saved as the default text header by pressing the **CONTROL – F10** keys then pressing **ENTER** twice. If **ENTER** is not hit twice, the text header information will not be saved. Once saved to the default text header this information will be saved with each file recorded until the text header is changed.

Note: Multiple text headers can be input into the program. This may be useful if you are attempting to get known calls from a number of species of bats or you have several sites where you frequently collect echolocation calls. The information applicable for each situation can be stored in its own text header for later retrieval. The inputting of multiple headers is accomplished by hitting the **T** key. Once all of the information is correct for a specific text header, it can be saved using the **F1 - F9** keys. Thus to save the first header, depress the **CONTROL – F1** keys and **ENTER** twice. The second text header can be

saved by **CONTROL – F2** keys and **ENTER** twice. These headers can be saved in any location between **F1-F9**.

These multiple text headers can be used in two ways:

1). In order to save a file with a specific text header, before the file is saved depress the **F** key with the desired text header saved to it and then hit **ENTER** twice. This option is only available in Record mode.

2). If a site is to be repeatedly sampled the text header can be modified by depressing the appropriate **F** key, making modifications, and saving to the default text header (by **CONTROL – F10** and **ENTER** twice).

MENUS

To bring up the Main menu of the Anabat program from the main Anabat screen push the **BACKSPACE** key. The Main menu lists the following options:

Configure menu – allows for the setup of the system for printers and other defaults for the Anabat program

Print menu – allows for printing of Anabat screens

Files menu – allows for the saving, loading, and deleting of different file types

Autosave menu – defines the criteria used to save files when the Anabat is in monitor mode.

New data – this option is used to bring you back to the main Anabat screen

These options can be selected by typing the first letter of the menu choice. The **ESCAPE** key can be used to return to the Main Anabat screen.

For all of the following menus, options can be selected by typing the letter that is capitalized in the option desired.

Configuration menu

Divn ratio – this option allows for the setting of the division ratio that is set on the bat detector. Note: this must be set to the same value as that selected on the bat detector in order to obtain useful echolocation calls sequences. If these values are not the same then the collected echolocation calls will not be useful. Commonly this is set at 16.

s**O**und out – this option toggles the output of the sound by the computer as echolocation calls are detected by the software. The (**y** or **n**) after this option indicates the currently selected output option.

Printer – this option allows for the selection of the correct printer driver. Once selected, a list of printer drivers is brought up. Use the arrow keys to move the cursor to highlight the correct printer driver and hit ENTER. You can also press the **ESC** key to abort his selection.

Zcaim params - allows for the control of the ZCAIM. The options are:

chose lpt **P**ort – allows for choosing the port that the ZCAIM is attached

Interrupt – informs the user of the interrupt setting being used by the ZCAIM

Choose Zcaim type – allows for the selection of ZCAIM types

Find zcaim automatically – allows for the computer to automatically locate the ZCIAM.

Automatic backup - toggles on the automatic backup option. If selected

Input port (1), interrupt (7) – identifies the port and the interrupt settings used by the Anabat program.

sa**V**e on cal (y) – this toggles the option of saving a file when a calibration tone is detected.

s**A**ve on exit (on) – this toggles the option of saving while exiting the menu

Cal freq – this allows for the input of the frequency of the calibration tone. This value is commonly placed at 40 kHz.

chang**E** scale (y) – this toggles the option of changing the frequency scale when another Anabat file is loaded

p**R**inter port (1) – when this option is selected a menu opens. This allows for the selection of the correct printer port

Backup drive (-:) – this is used to select the disk drive that the backup will be saved to when a backup is done.

Save now – allows for the saving of settings

Print menu

Print image – allows for the printing of the current displayed pic file (see **P**ic file save below)

Autoprint files – prints all of the pic files located in the current directory

Files menu

Save sequence file – when this is selected it allows for the editing of the text header of a file. Once the text header is input and entered into the buffer (see above section), this option saves this detected echolocation call sequence.

Load sequence file – allows for the loading of an already saved Anabat file so that it is displayed on the Anabat graph.

Pic file save – saves the current displayed portion of the loaded Anabat file into a picture file. This picture file is saved with the current data and time just like the regular Anabat files. However, the extension is the second on the computer clock followed by a %. This picture file can be loaded into the Anabat program, but this file can not be edited. This file type is only for printing of an Anabat screen with a portion of an echolocation call sequence on it. This can be printed using the commands under the Print Menu above.

Recall pic file – loads a previously saved picture file into Anabat. This file cannot be edited, only viewed.

re**N**ame sequence file – allows for the changing of the filename of the currently loaded Anabat file. Once this is selected the user is prompted to confirm

this option. If **y** is depressed, then the user is given the opportunity to alter the filename.

re**W**rite sequence file- allows for the text header of the currently loaded Anabat file to be altered. This can be saved to the same filename.

Delete sequence file – deletes the currently loaded Anabat file.

<u>Autosave menu</u>

Slack – this value defines how close to a straight line the points are on the screen before the Anabat program identifies the data points as part of an echolocation call. Once data points are identified using this criterion, the time to save an echolocation call sequence is defined in the following items.

Between calls max – this values determines the amount of time that must pass between calls for a sequence to be saved. Good setting is 2000ms.

minimum Line length – this value determines the minimum number of data points that can be included in a line.

Max slope (260) OPS (6) rows – this value determines the maximum vertical distance (change in frequency) between two data points for them to be considered two data points in the same line.

There are two additional criteria that are used to save echolocation calls while in Monitor mode.

The buffer fills up. The buffer size is the number of data points within an echolocation call sequence. The maximum number of data points within a file is 16384. When an echolocation sequence fills with the maximum number of data points, the file is saved while in monitor mode.

A time limit – The Anabat program saves an echolocation call sequence after more than 15 seconds have elapsed since the start of the call sequence.

COMMANDS

Display

SPACEBAR – toggles between truetime and compressed time.

ESC – key resets the display of the screen to a 16 second time display

BACKSPACE – opens up the Anabat Main menu screen. (Main menu options are described in earlier section).

F (1-10) – keys adjust the amount of time represented on a single computer screen from 16s (**F1**) to 16ms (**F10**).

1-9 and A-F – skips to corresponding location on the x-axis on a loaded Anabat file so that this point is viewed on the left edge of the computer screen.

+ - key increases the frequency range displayed on the y- axis

- - key decreases the frequency range displayed on the y- axis

Right and Left ARROW keys – scroll through the currently displayed file

K – key allows for the determination of the display mode. There are several options for specifying the way the time between calls is displayed:

K = compressed mode

1 = expanded 2 times

2 = expanded 5 times

3 = expanded 10 times

4 = expanded 20 times

by expanding the display, the echolocation calls are seen in more detail.

B –key pages through the echolocation call sequence one call at a time.

CONTROL – [returns the Anabat screen to the 16 second display on the main Anabat screen

TAB – toggles between cursor that only moves when detecting an echolocation call or one that continually moves

ALT – (1-0, A-E) this command serves to move the selected area on the time scale **(1-0, A-E)** so that it is at the right hand of the display screen.

END – redraws the Anabat screen

HOME – return to the beginning of the file

File management

SHIFT – L lists files in the selected directory for loading into Analook.

TAB moves among directories

LEFT AND RIGHT ARROW keys – moves cursor to select a directory or file

ENTER shows files in selected directory

ENTER opens highlighted file into Analook

ALT – D deletes the current Anabat file. Once pushed, the user is asked to confirm the delete by pressing "Y" or cancel by pressing "N"

CONTROL – D deletes the selected file. Before the file is actually deleted, there is an option for the user to confirm the deletion by pressing Y or canceling the deletion by pressing N.

[once a file is loaded this key can be used to bring up the previous file in the current directory.

] once a file is loaded, this key loads the next file in the current directory. These two keys allow for the quick scanning of all of the Anabat files in the current directory

CONTROL – U makes a backup of the Anabat files in the current directory to the designated directory indicated in the Configure menu

S- key saves the detected echolocation call sequence to a file

CONTROL – X exits the Anabat program

Editing and parameter extraction

Delete – key allows for the removal of some portions of the displayed call. When depressed, a line appears on the left of the screen. Move this line (using the right and left arrow keys) to the left edge of the material you want to keep and hit Enter. A line will then appear on the right side of the screen. Move this line so that the section of the file you want to keep is between the two lines and hit Enter. The portion of the file between the two lines will then be saved to a separate file with the filename consisting of the current time and date. This is useful when two bats are recorded in

the same Anabat file. <u>However, care should be taken to maintain the original time and date associated with newly created files edited in this manner.</u>

W – key allows for the exclusion of calls in a sequence shorter than the specified time. Useful in removing fragmentary calls.

Q – key displays the measurements of three parameters in the middle line of graph heading. The parameters are duration, TBC [time between calls], and frequency. The frequency listed is the frequency of the line that appears on the screen. This line can be moved to allow for the frequency determination at a specific point in the echolocation call sequence.

H- key toggles a horizontal reference line on and off. This line can be moved up and down (using the arrow key) to obtain values of the frequency at specific points in the files (i.e. minimum frequency of a call).

Shift – W allows for the removal of calls that are longer than the selected time

L – key brings up vertical lines which mark the start of each echolocation call on the screen.

Z – key edits the echolocation sequence by removing echoes and other extraneous noise. *Note: this command (as well as the equivalent Analook command) may not remove everything that needs to be removed or may remove material that should be left in. Care must be taken in the use of this key. We find that it is most useful in observing the quality of the sequence, but not for the actual analysis.*

X – key excludes calls based on their frequency. When depressed a horizontal line appears. This line can be moved to a specific point and the following options can be selected:

The first choice is the amount of the call that must be indicated by the position of the line in order to be deleted. The options are none, some, most, whole. Once this option is selected hit the **TAB** key and you can choose between the above and below options. To finish the selection just push **ENTER**.

SHIFT – H toggles between manual and automatic frequency cursor

SHIFT – X excludes selected calls from an echolocation call sequence (see description on X – key above)

V –key toggles a vertical reference line on and off. This reference line can be used to gain estimates of the structure of a loaded echolocation call.

Record modes and text headers

SHIFT – N enters record mode (see section above on recording modes)

CONTROL – N enters monitor mode (see section above on recording modes)

SPACEBAR removes Anabat from record or monitor mode

T- key allows currently displayed file's text header to be edited (see section above for more detailed description of the options available).

Miscellaneous

R – key allows for the automatic relocation of the calibration tone when a tape recording is played through into the computer through the ZCAIM. This is useful in correcting the frequencies recorded that are altered by the tape player (low batteries, tape problems, etc.)

Shift – R allows for the manual altering of the calibration tone to correct for errors in its detection from the tape player (i.e. slow batteries, used tape)

P – key brings up the print menu (print menu options described above)

U- key undoes last command

SHIFT – V toggles between manual and automatic time cursor

CONTROL – H brings up Main menu (also /, **SHIFT -**/)

M – key allows for the adjustment of the volume of the playback of an echolocation call. The volume ranges form off (**0**) to highest (**5**). Once the volume is selected push enter to return to the main Anabat screen.

SHIFT – F(1-0) replays the currently loaded Anabat call sequence through the computer's internal speaker. This sound is divided by the selected division ratio to produce an audible sound. By selecting different function keys, the sound is played back at varying speeds.

Shift – F1 replays at normal speed

Shift – F2 replays at 1/2 normal speed

Shift – F4 replays at 1/4 normal speed

Shift – F5 replays at 1/5 normal speed

Shift – F8 replays at1/8 normal speed

Shift – F9 replays at 1/16 normal speed

Shift – F10 replays at 1/10 normal speed

ANALOOK

The Analook program is initiated by typing Analook at the DOS prompt or by using the run option under the Start menu in Windows. The introductory Analook screen shows the information on the version, date, and the author of this program (Chris Corben). To bring up the main Analook screen press any key. The main Analook screen is a time (X-axis) – frequency (Y-axis) graph. For each of these axes, the scale can be changed to allow for different views of the displayed echolocation call. The frequency scale is log transformed to allow better visualization of the structure of the echolocation calls. The bottom of the screen provides the following parameters:

TOT – indicates the total amount of time represented by a single computer screen.

TK – indicates the time value of each major tick mark on the x - axis

F – indicates which Function – key (f1-8) was used to select the displayed combination of TOT and TK values.

COMP/REAL this indicates the current time display. True time shows the sequence as it was detected. Compressed time shortens the interval between pulses being displayed to maximize the number of pulses displayed on a single screen.

St – indicates position of a specific point (cursor, echolocation call) within the Anabat file. It functions as a counter and is useful in returning to a particular location within an Anabat file.

FILT – indicates the specific filter used to display the file as it is. Different filters are used to remove unwanted material (echoes, fragments, etc.) from a displayed file. These modifications only alter the display of the screen and not the original Anabat file.

ANALOOK COMMANDS

BACKSPACE – opens up the Analook help screen menu.

(help screen is also brought up by pressing the /, **?**, **ALT–H**, and **Ctrl–H**)

The Analook Help screen menu consists of the following options:

1. Display manipulation
2. File marking keys
3. Text header manipulation
4. File loading
5. Editing and parameter extraction

To exit the help menu press ESC.

1. Display manipulation commands

F (1-10) – adjusts the total amount of time displayed on a single computer screen. This also alters the amount of time represented by each tick on the X –axis of the Analook display.

#0- 9 and **A-F** – moves the selected location (1-9, A-F on the X-axis) to the left-hand margin of the screen.

ESC – returns the display to real time and changes the total time displayed on the Y- axis to 15 second (F1 value)

SPACEBAR – toggles between real compressed time.

RETURN – redraws the graph of the currently loaded Anabat file

+ - key decreases the maximum frequency displayed on the Y-axis (80 minimum)

- - key increases the maximum frequency displayed on the Y-axis (200 maximum)

RIGHT/LEFT ARROW keys – moves to next/ previous pulse in the currently displayed Anabat file

HOME key – return the initial part of the file to the left hand side of the screen.

SHIFT – V doubles the division ratio every time it is pushed (<u>do not push</u>), reversed by hitting the ESC key.

CONTROL - B adjusts the size of the pixels used to display the current file. Three different pixel sizes are available, one with each subsequent depression of these keys. Adjusting the pixel size enhances the image of the individual calls within a sequence.

PAGE UP – applies the currently opened filter

PAGE DOWN – unapplies the currently opened filter to return the file to an uncleaned state

ALT – O opens up the options menu which contains the following options:

1. Colors – bring up a submenu that allows for the colors of different aspects of the display (background, axes, echolocation calls, etc.) to be customized. There are also several defined color schemes for the Analook display.
2. Slope Params – allows for the input of the # maximum number of transitions for the determination of slope parameters
3. TBC Params – adjusts the Time between calls (TBC) (below)
    a. Gap – size of a gap in the TBC to be ignored in the TBC calculation
    b. Scale – allows the selection of linear or logarithmic display
    c. Time/Frequency – selects either time or frequency (histogram) as the Y axis of the TBC display
    d. Max – allows for the determination of the maximum value on the Y –axis of the TBC display
4. Show off dots (y/n) – toggles between showing and not showing points in the echolocation call sequence that have been removed from consideration through the use of a filter or edit menu
5. Division Ratio – allows for the reduction of the division ratio for a file.

2. <u>File marking keys</u>

ALT- M marks the file. When a file is marked a shaded box appears to the right of the filename located at the lower left corner of the Analook screen. This command can also be use to unmark a previously selected file. Several functions can be applied to marked files including:

ALT – U unmarks all selected files

ALT – G allows for the global change of the text headers for all marked files

ALT – C copies all marked files to another directory.

ALT – V moves all marked files to be moved to another directory. There is the option of deleting for the old directory all of the files that are moved.

ALT – R reverses the selection of the files. All marked files are unmarked and vice versa.

ALT – D deletes all marked files. Before the files are actually deleted, there is an option for the user to confirm the deletion by pressing Y or cancel the deletion by pressing N.

Shift - L can be used to view all currently marked files simultaneously. In addition files can be marked and unmarked from this screen, however the options of file manipulation can only be performed from the main Analook screen with an file loaded in memory.

ALT – F – opens up the file menu

Mark - marks all files in the current directory that contain non-empty species fields in the text header

Disperse – allows for the movement of known calls simultaneously. Before this is done all files with non-empty species fields must be selected. After hitting “Y”es for the permission to proceed, the program scans through the current directory of files for necessary subdirectories. These subdirectories will have the same name as

the data entered in the species fields of the text header. Then the program will move all the selected files into the appropriate subdirectories.

3. Text header manipulation

T- key allows currently displayed file's text header to be edited (ESC returns to main Anabat screen). This can be altered the same way as in Anabat.

4. File management

ALT- T saves copy of the currently displayed sequence of a particular file with the .TIF extension in the current directory. This extension indicates that the file is a picture of the displayed sequence that can be imported into a variety of graphic computer programs to generate reports or slide presentations.

SHIFT – L lists files in the selected directory for loading into Analook.

TAB moves among directories

LEFT AND RIGHT ARROW keys – moves cursor to select a directory or file

ENTER shows files in selected directory

ENTER opens highlighted file into Analook

M – allows for the creation of a new subdirectory

SHIFT – { loads a previous file in the current directory that has the same info for the species label in the text header

] - when viewing a file on the frequency – time scale, this key loads the previous file in the current directory into Analook.

SHIFT - } loads a next file in the current directory that has the same info for the species label in the text header

] - when viewing a file on the frequency – time scale, this key loads the next file in the current directory into Analook.

CONTROL – D deletes the currently loaded Anabat file. Before the file is deleted, there is an option for the user to confirm the deletion by pressing Y or canceling the deletion by pressing N.

5. Editing and parameter extraction

There are two structural components of an echolocation call that need to be defined so that the basics of editing and parameter extraction can be understood. The knee is the point in the call at which the slope changes from mostly vertical to mostly horizontal. The body of an echolocation call is the flattest portion of the call (area with smallest change in frequency).

Z – key applies filter similar to preset filter #1 to automatically clean a loaded call sequence. Care must be taken when using this key because the method the program uses to determine what to keep and what to remove is sometimes inappropriate. This means that valuable data may be lost or, alternatively, some trash calls will remain in the call sequence. This key can be used to scan through call sequences to determine their quality. However it is much better to utilized a custom filter for obtaining numerical values of selected parameters (see filter menu below).

Q – key gives calculated parameter values for echolocation calls currently displayed on the screen. Again these values are displayed on the bottom of the screen and represent averages of the parameter values for all of the calls displayed.

M – key gives the value of each parameter for the calls currently displayed on the screen. The values are averages of all of the calls on the screen. They are displayed under the graph at the bottom of the screen. To return the text header press the M key again.

CONTROL – Q saves the values of the measured parameters to a text file named Params.txt

V- key splits the screen. The left screen is the truncated image of the 'normal' Analook screen and the 'new' right screen may be either of two optional screens. The specifics of these two screens can be adjusted using the Option menu (see above).

CONTROL – F1 shows the slope of the entire call for all of the calls on the screen to the left. This is useful in distinguishing species when using the qualitative approach (Figure 3).

CONTROL – F2 shows a histogram of the time between calls displayed on the screen. This may be useful in examining the behavior associated with the displayed echolocation (Figure 4). Values can be altered in the **ALT-O** menu (pg. 37).

ALT – (1-0) applies different filters to the currently displayed file. Filters serve to edit material out of the file in an attempt to clean up the call sequence. Each filter uses a different set of criteria to clean up the sequence. Care should be taken when applying different filters to an echolocation call sequence so that pertinent material is not deleted in the cleaning process. To return to normal viewing press the Page Down – key.

ALT – F - opens the file menu. There are two options dealing with cleaning files

Purge – removes all of the data that is Marked Off dots (by filter or by edit menu) from the display memory. The original data file retains all data points and the Marked Off dots can be reloaded by reloading the file. For as long as the file is loaded, this option allows for the elimination of re-cleaning the file if an incorrect button is pushed.

Save – allows for the saving of the current display conditions of a file. If the Marked Off dots are not displayed when this key is pushed, then each time the file is saved the Off dots will not be displayed, but the Page down key will display those data points. However if this key is pushed after the file is purged (see above) then the Marked Off points are permanently removed from memory.

ALT – E opens the edit menu. Once the file is loaded into Analook depress ALT – E and then move the mouse to the area of the text header. A new menu will appear in its place. However, this new menu will quickly disappear when the cursor is moved away from this menu area. To exit edit mode press ALT – E. (Figure 6).

ALT – B opens the new filter menu. This menu allows for the construction of a customized filter for the quantified cleaning of echolocation calls. This menu is described below.

EDIT MENU

Move left – scrolls left through the echolocation call sequence.

Send to file - after the file is cleaned up (objects which are not useful calls are marked off), this option is used to send the parameter values for each pulse to a text file. This only serves to send data to the text files on those pulses that are currently displayed, thus each screen of the call sequence must be cleaned and sent to the text file separately. This file is entitled PARAMS.TXT. When other portions of the same call or other calls are cleaned up and values sent to the text files, these later additions are added to the end of the file. Thus all of the cleaned call parameter values are sent to the same file. This files is saved in the directory that the cleaned files are located.

Modify bodies – this selection is used in altering the structure and components of the echolocation call. It can be used to change the location of the body or to add or delete points in the echolocation call. Note: caution must be taken with the use of this command, due to the ability to significantly alter parameter values of an echolocation call.

The following four commands utilize the same procedure to allow for editing and parameter extraction. Once one of these options is selected, use the mouse to move the cursor to one corner of a box that includes the appropriate selection material. Click the left mouse button and hold it down while dragging the cursor to the opposite corner of the selection area and let off the mouse button. This selects an area to be edited by use of the following commands.

Mark to exclude – excludes all data within the selected area from parameter calculation. This option removes the entire pulse if even a section of the pulse is included in the box.

Mark to include – includes all data within the selected area in parameter calculation. This option retains any pulse that has even a portion of it selected in the box.

Mark Off points – allows the user to manually exclude individual points from parameter calculation.

Mark ON points – allows the user to manually select points for inclusion in the calculation of parameter values. This is most commonly used in reselecting points that were inadvertently "Marked Off" in the editing process.

Move right – scrolls right through the echolocation call sequence.

After an item is selected from the edit menu, the selected menu option appears in the lower right hand corner of the screen. This allows for confirmation of which editing option is currently selected.

When two or more calls are edited at the same time, measurements recorded on the screen are averages of all of the parameters for these calls. However, not all of the parameters displayed on the screen are sent to the text file. For those parameters that have values sent to the text file (those parameters marked with an *), each individual pulse has its information saved to a separate row within the text file.

FILTER MENU (**ALT-B**)

There are five options under this menu. Each option is selected by depressing the first letter of the desired option.

1. **N**ew – this option allows for the creation of a new filter. There are three options:
    a. **C**all – allows for the parameter values to be modified to create a customized filter for the cleaning of echolocation calls
    b. **B**uzz – allows for the designation of parameter values for the cleaning of a feeding buzz
    c. **N**ame – allows for the naming of the newly constructed filter. The name of the filter must be changed in order to be saved.
2. **O**pen – loads the parameter values of a previously constructed filter into memory. This allows for the editing of existing parameter values or the application of this filter to recorded Anabat files.
3. **S**ave – permits the new parameter values of a filter to be saved for future use. This filter will have the name that was previously assigned (See 1c. above) and will be located in Anabat directory.
4. **E**dit – Once a filter is loaded into memory (either by creating of opening a filter), this option is used to modify the previously assigned parameter values.
5. **A**pply – Once a filter is loaded into memory, this option allows for the application of this filter to each loaded Anabat file.

Description of parameters that are calculated by the Analook software.

N – the number of echolocation pulses that were included in the parameter measurement.

St – is a counter of the echolocation call in a file. This value allows for the location of a specific call in a sequence for comparison with the measured parameters

*S1 – the slope calculated from the initial five points in an echolocation call

*Sc – the slope of the body

Qu – the quality of the echolocation call. This parameter attempts to quantify the quality of the echolocation call. As it is currently measured, this parameter is not useful in assessing the quality of the echolocation call.

*Fmax – the highest frequency attained in an echolocation call

*Fmin – the lowest frequency attained in the echolocation call

*Fmean- the weighted average of the call; thus it takes into account the frequency as well as the time each portion of the echolocation call spends at each frequency

*Fc – the characteristic frequency of the call; this is the frequency of the body of the call.

*Fk – the frequency of the knee

*Dur – duration of the echolocation call

TBC – the time between calls

Ntbc – the number of ticks between calls

*Tc – duration of the body of the call.

*Tk – is the time from the initiation of the call to the knee

Qk – the quality of call at the knee. This parameter attempts to quantify the quality of a particular call structure (the knee). This parameter is not reliable in assessing the quality of the knee of an echolocation call.

Figure 3. Example of the use of the slope screen in Analook.

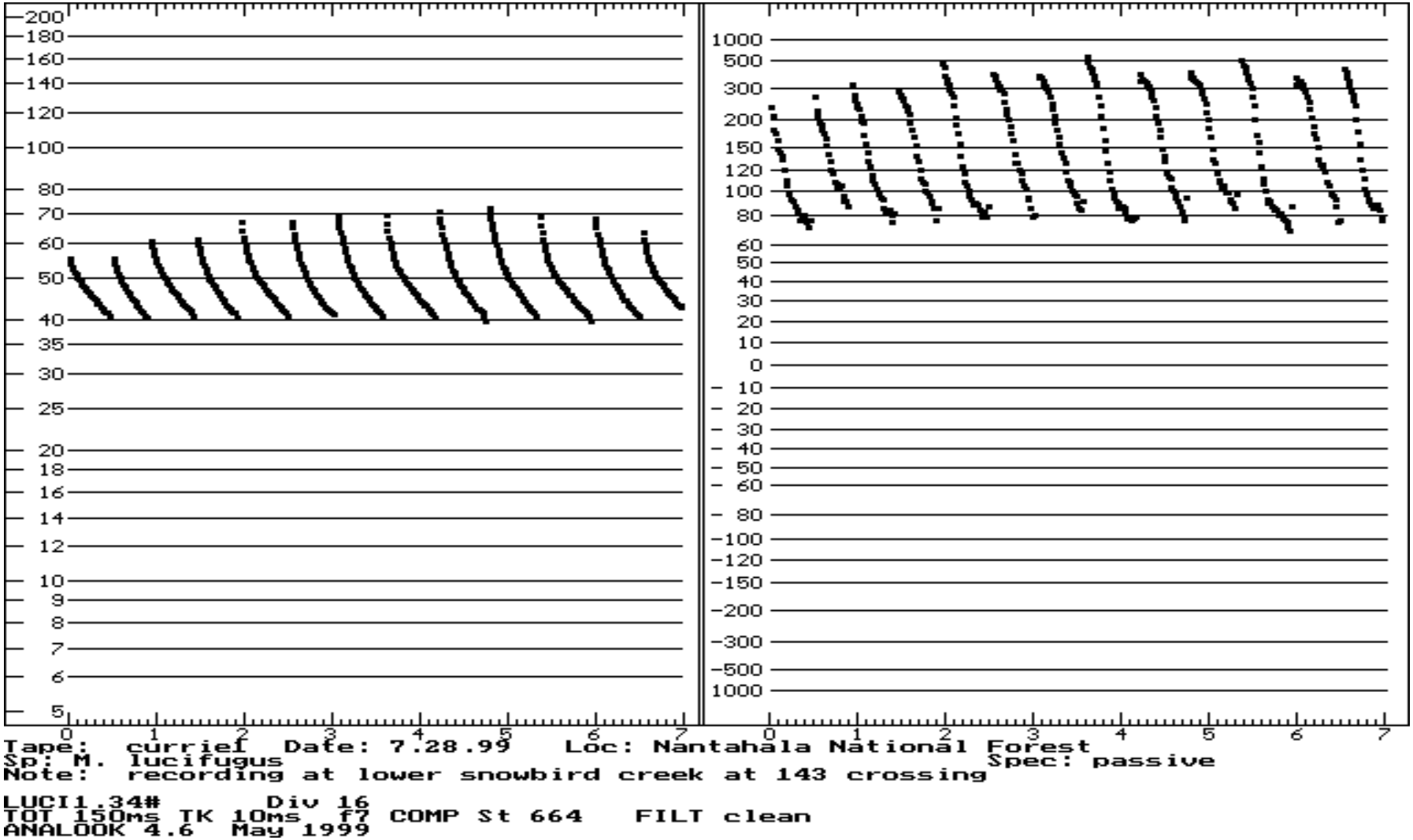
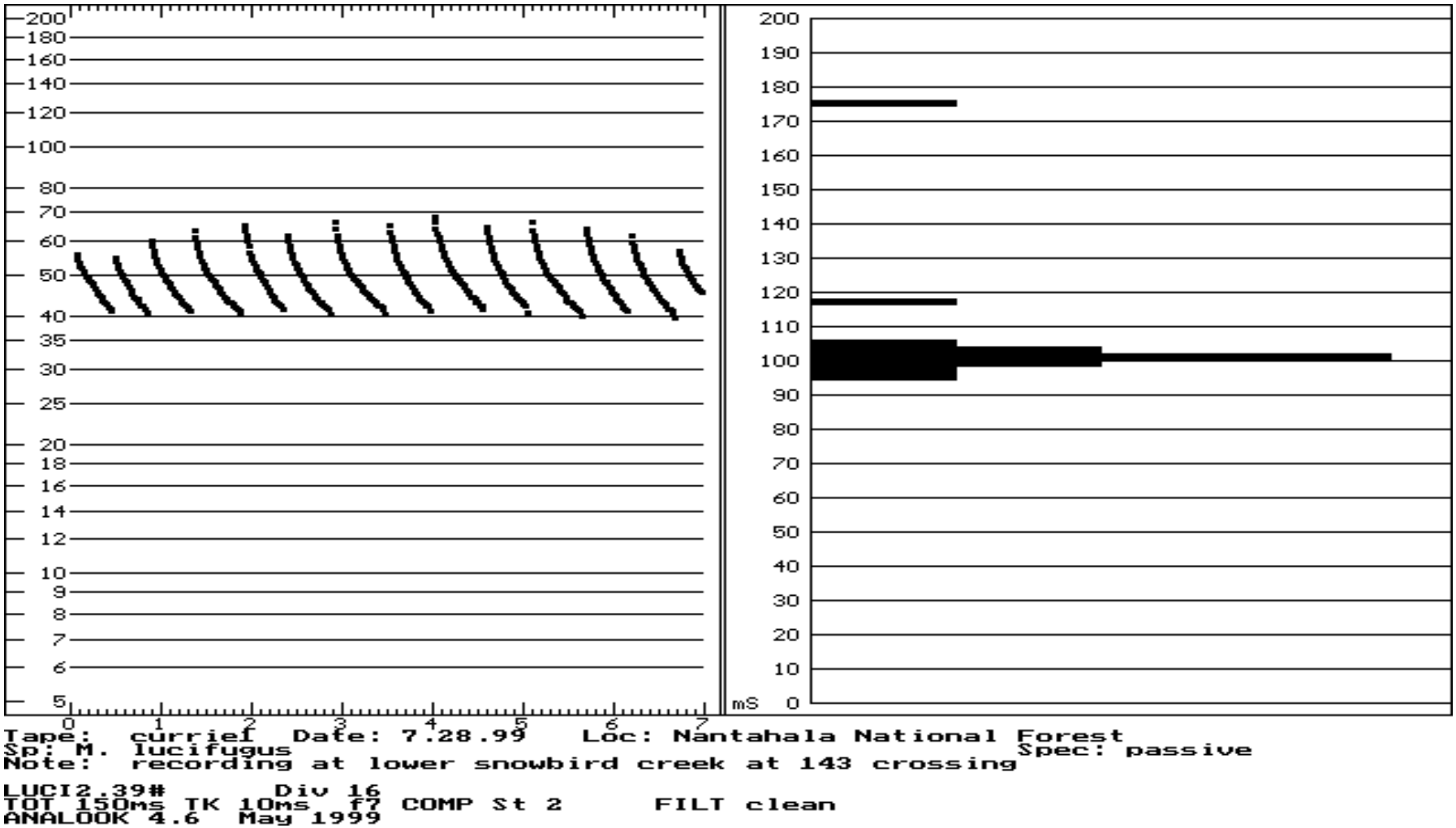


Figure 4. Example of the time between calls screen in Analook.



Appendix A. Technical references on the installation of software, troubleshooting, DOS commands, and Anabat and Analook command list.

A1. INSTRUCTIONS TO INSTALL THE ANABAT PROGRAM ON THE HARD DRIVE OF YOUR COMPUTER

Bold indicates information to be typed or specific keys to be used by the operator.

1. Push the power button on your computer. If your computer starts up in DOS, then just let the computer boot up completely. If your computer starts with WIN95 then follow the directions in Appendix section A3 step I to start DOS.
2. Change to the C prompt (C:\>) by typing **C:\>**.
3. Make an Anabat directory on your hard drive by typing
   C:\> **md\anabat {enter}**
4. Insert the Anabat program floppy disk into the disk drive.
5. Copy the Anabat files from the floppy disk into the newly created Anabat directory by typing the following:
   C:\> **copy a:\anabat6*.* c:\anabat {enter}**
   Note: this command may need to be altered to reflect the letter of the floppy drive in the first section. (change the a:)
6. Verify that the copy was complete
   C:\> **cd\anabat {enter}**
   C:\anabat> **dir {enter}**

If the files were successfully copied there will be a number of files in this directory. If no files are present in this directory, then attempt to recopy the files while paying special attention to the syntax of the commands.

A2. INSTRUCTIONS TO CHANGE THE AUTOEXEC.BAT FILE TO ALLOW FOR THE START OF ANABAT FROM ANY DIRECTORY

1. From the C prompt use the edit command in DOS.
   C:\> **edit autoexec.bat {enter}**
2. Use the arrow keys to move the cursor to the end of a line that starts with the command path. Example of path statement: path=c:\dos; c:\windows;
3. Move to the space immediately after the last semicolon and type; **C:\anabat**
4. Use the arrow keys to the end of the file and type **date** and **{enter}**
5. Type **time** and **{enter}**
6. Then hold the **ALT key** down and hit the **F key**
7. Use the **arrow keys** to move the cursor to save and hit **{enter}**
8. Press **ATL – F** KEYS
9. Use the **arrow keys** to move the cursor to exit and hit **{enter}**
10. You should now be back at the C prompt

The sections A1 and A2 are only required during the initial installation

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A3. QUICK REFERENCE TO STARTUP AND RECORDING PROCEDURES

Checklist for the setup of the Anabat system

I. Turn on the computer.

   A. If it starts up in Windows 95, then there are 2 ways to start DOS.

      1. When first booting up, the phrase STARTING WINDOWS95 appears in the upper left-hand corner. At this time, hit the **F8** key several times. If you managed to do this in time, a menu will pop up. Use the **arrow keys** to go down to the option entitled COMMAND PROMPT ONLY and hit **Enter**.
      2. If WIN 95 has already progressed past this point, then allow Windows 95 to fully load. Once loaded move the mouse to the start button located in the bottom left of the screen. **Left click** on this button. Then use the mouse to select the Shut down menu option and **left click**. Move the cursor to the circle next to the restart computer in MS-DOS option and select it by **left clicking** while the cursor is in the circle. After it is selected then **left click** on the OK box at the bottom of the screen. The computer will then restart in DOS and you can continue with the checklist below (step II).

   B. If your computer boots up directly to DOS;

      1. At the C prompt change to the directory to which you want the Anabat files saved. (example if you want the files saved to the directory bats99\missouri\may20 then you would type cd\bats99\missouri\may20 then **ENTER**
      2. Type **anabat6** and **ENTER**

   You should now see the introductory Anabat screen. Press any key to get to the main Anabat screen

II. Turn the bat detector on and make sure that the low battery light is not illuminated. In addition, rub your fingers in front of the microphone. If working properly you will hear noise produced through the internal speaker of the bat detector. If you do not hear any sound produced then check the volume to make sure it is turned up and check the battery in the bat detector.

III. Set the sensitivity of the detector at the highest level (usually 4-7) allowed by the habitat and conditions (i.e. as determined by the amount of extraneous noise present)

IV. Turn the ZCAIM on and set to a sensitivity of at least 10. At any value lower than this the ZCAIM will not function properly.

V. Attach the cable to the bat detector and the ZCAIM

VI. Connect the parallel cable that connects the ZCAIM and the parallel port on the back of the computer

VII. Press **T** to enter the text header. Once all the current information is in the text header press **CTRL - F10**. Then hit **{enter}{enter}**. This saves the text header and should bring you back to the main Anabat screen.

VIII. Select the desired mode of saving files (record {shift–n} or monitor {ctrl–n})

IX. Rub your fingers in front of the microphone to determine if the sound detected by the microphone is translated to the Anabat screen.

X. If this does not work start with the checklist outlined in Appendix section A4.

A4. TROUBLE SHOOTING PROBLEMS WITH THE ANABAT SYSTEM

I. An error message that reads "no ZCAIM found" appears in the upper left-hand corner of the computer screen when attempting to initiate a recording mode in Anabat.

A. Check that the sensitivity on the ZCAIM is turned up to at least 10.

B. Check that the parallel cable is attached to the computer and ZCAIM correctly and snugly.

C. Check the batteries in the ZCAIM. The ZCAIM has a low battery light that illuminates when the batteries are getting low. However, if the batteries are completely dead then the low battery light will not illuminate. Testing of the batteries in the ZCAIM is easily done by turning on and connecting the bat detector and ZCIAM units and rubbing your fingers in front of the microphone. If everything is turned on and the connection and batteries are good then a green light is illuminated on the ZCAIM.

D. If this still does not fix the problem then exit the Anabat program.

E. When back in DOS restart the Anabat program and attempt to initiate the desired record mode again.

F. Hit any key to return to the main Anabat screen and try to initiate the desired recording mode again. If all of these steps have been checked and there is still a problem, then replace the connecting cable and check again.

II. Nothing is being recorded.

A. Check that the desired sensitivity on the bat detector is selected (usually 4-7).

B. If the desired recording mode is successfully initiated, then the problem is either in the bat detector or the connecting cable.

C. Check that the batteries are functional by rubbing your fingers in front of the microphone. With the volume turned to about 5, an audible sound is produced if the batteries are good. If no sound is produced then change the batteries and attempt to initiate recording with the Anabat system.

D. If sound is produced through the external speaker on the bat detector, then the problem is in the connecting cable.

E. Check to make sure that it is properly attached. If it is then replace this cable.

III. When files are saved there is a lot of extraneous noise present in the detected calls. This problem is present because:

A. The sensitivity on the bat detector is set too high for the location. Turn the sensitivity down until the extraneous noise is nearly eliminated.

B. The placement of the Anabat system is inappropriate. Try moving the Anabat to a location or at least a direction that limits the exposure to extraneous noise. (In addition to STEP 1 above).

A5. A LIST OF FREQUENTLY USED DOS COMMANDS

Filename - is the name of the file. It is located on the left of the period and in DOS is limited to a maximum of 8 characters.

File extension - is the three characters present to the right of the period in the complete name of the file. The file extension encodes the type of the file.

* - this key is a wildcard in DOS. This can be used to select a large number of files or a certain file type etc. Examples are included below in the <copy> and <dir> commands.

Copy – this command allows the user to copy files to different directories or to a separate disk. The general format of this statement is

copy {present location of item to be copied} {new location of copied item}

Examples:

copy a:*.* c:\anabat - copies everything on the A drive to the Anabat directory

copy a:\anabat.* c:\anabat - copies all files with filename of Anabat regardless of the file extension to the Anabat directory

copy a:*.com c:\anabat - copies all of the files on the A drive with the file extension .com to the Anabat directory

CD – this command allows the user to move between directories. There are several uses of this command.

cd\bats99 – moves to the bats99 directory

cd\bats99\missouri – moves to Missouri directory under the bats99 directory if you aren't in the bats 99 directory.

cd Missouri – moves to the Missouri directory when you are already in the Bats99 directory.

cd .. – moves back one directory in the directory structure

cd\ - moves to the C prompt

DIR – this command is used to list the contents of the current directory. There are several specific uses of this command

Dir *. - lists all of the directories inside the current directory

Dir /p - lists the files of the current directory one page at a time

Dir /w - lists the files of the current directory in 4 columns across the screen

MOVE – this command is used to change the directory where a file is located

Ex. To move a file from the bats99 directory to known directory

move c:\bats99\file.000 c:\knowns\file.000

A5. Cont'd.

RENAME – this command is used to change the name of a file

Ex. To change the name of a file from file.000 to changed.000 both in the bats99 directory

Rename c:\bats99\file.000 c:\bats99\changed.000

HELP – this command brings up the help screen for DOS commands

DEL – this command allows for the deletion of selected files

Examples:

del c:\file.000 deletes the file.000 from the hard disk
del c:\file.* deletes all files with the filename file
del c:\bats*.* deletes all files in the directory bats

TIME – this command is used to adjust the internal clock kept by the computer

DATE – this command allows for the adjustment of the internal date kept by the computer

MD – this command allows for the creation of a directory

md\bats creates a directory named "bats"
md\bats\22june creates a 22june directory

RD - this command allows for the removal of empty directories

rd\bats\22june removes the directory 22june from the bats directory

NOTE: the directory must be empty before it can be removed

Just type the drive letter followed by a colon and enter to change drives

Example of file directory structure.

- Bats00
  - Arkansas
    - 27may
    - 28may
  - North Carolina
    - 3june
  - Knowns
    - NC
      - sodalis
      - borealis
    - NY
      - leibii
      - subflavus

A6. COMMONLY USED COMMANDS FOR BOTH ANABAT AND ANALOOK SOFTWARE.

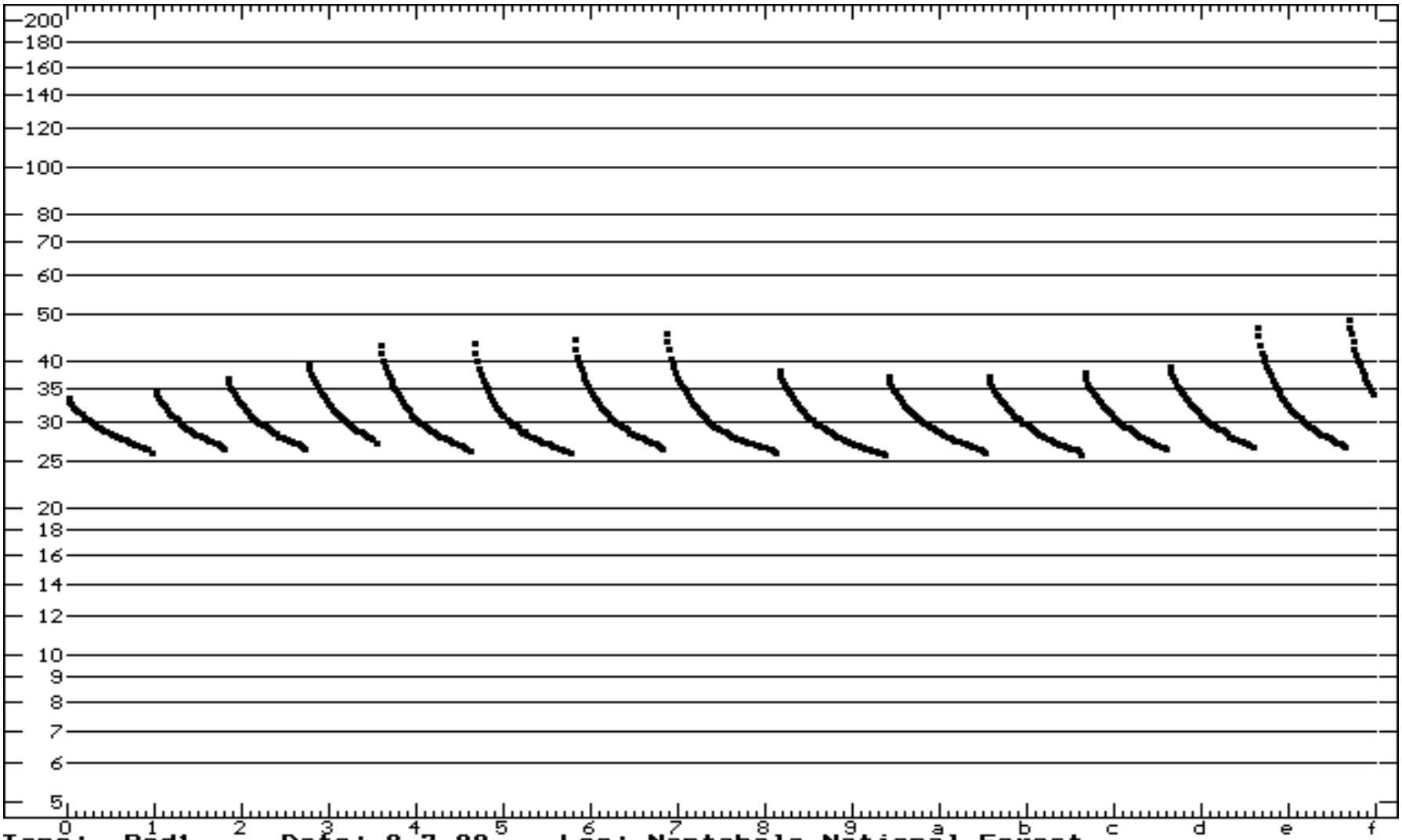
ANABAT COMMANDS

CONTROL – N	enters monitor recording mode
SHIFT – N	enters manual record mode
T - KEY	Allows for the editing the text header
CONTROL – F10	saves the text to the default text header
ENTER AND ENTER	exits the text editing screen
S – KEY	saves the detected echolocation call when in manual record mode
SPACEBAR – KEY	toggles between real time and compressed time display modes; also serves to end the recording mode and go back to the main Anabat screen
F (1-8) keys	changes the time scale represented on the x-axis on the main Anabat screen
CONTROL – X	exits the Anabat program
+ or – keys	changes the frequency scale represented on the y-axis of the main Anabat screen
SHIFT – L	allows selection of an Anabat file to be loaded into Anabat
[or]	loads the previous ([) or next (]) file in the current directory into Anabat

ANALOOK COMMANDS

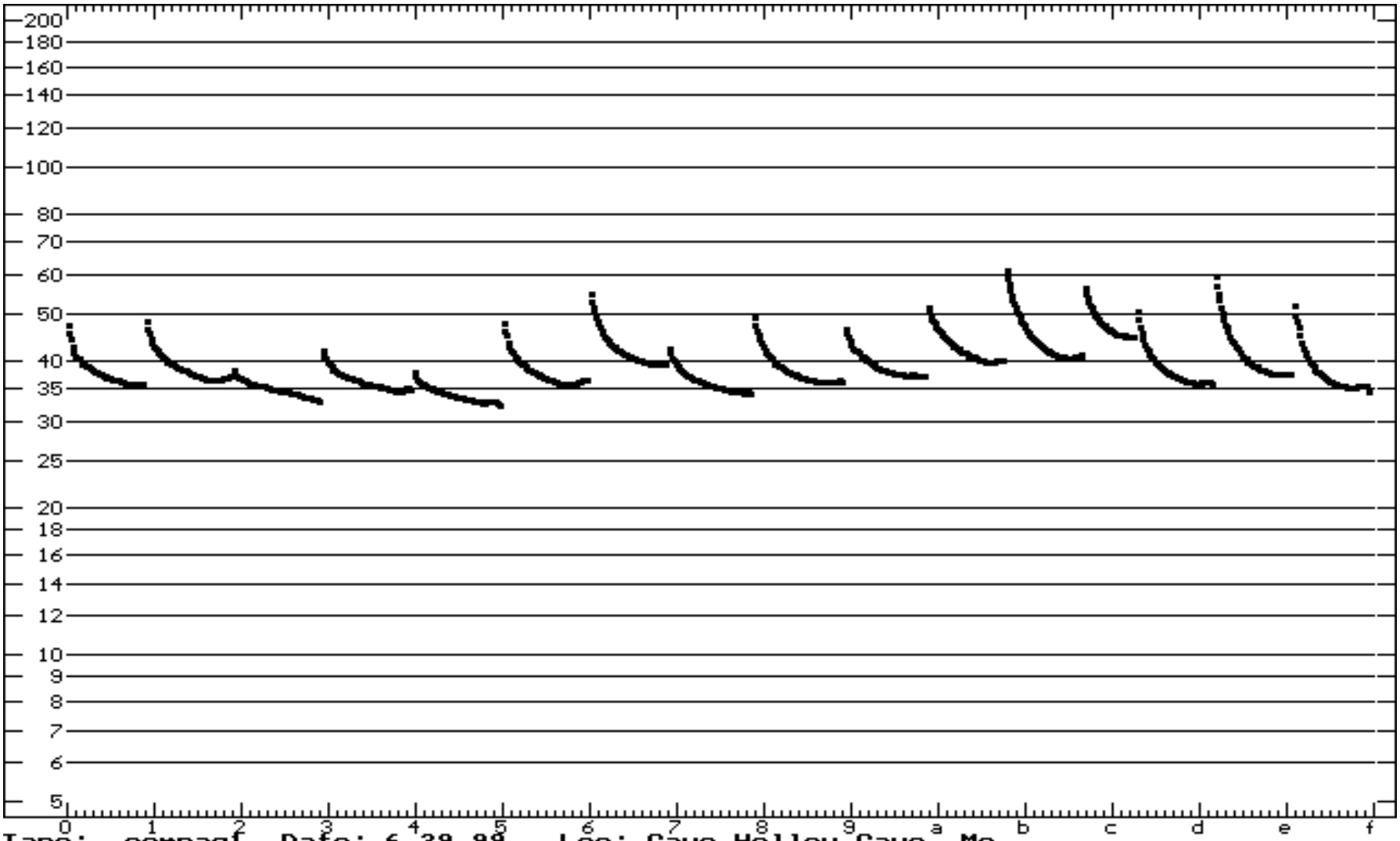
SHIFT – L	list Anabat files present in the selected directory. The appropriate file can then be selected and this file will be loaded into Analook for analysis.
ALT - E	enters edit mode for quantitative analysis of the loaded file
CONTROL – X	exit the Analook program
F (1-8) keys	changes the time scale represented on the x-axis on the main Analook screen
SPACEBAR – KEY	toggles between real time and compressed time display modes; also serves to end the recording mode and go back to the main Analook screen
M- key	measures valuies for parameters that are calculated by Analook. These parameter values are for calls displayed on the curerent Analook screen. The values for these parameters are displayed n the text header region of the analook screen.

Appendix B. This appendix contains examples of the search phase echolocation calls of 10 species of bats found in the eastern United States. These screens were taken from Analook and are displayed in compressed time to allow multiple calls to be displayed on the screen at once. The extraneous noise was removed form these sequences through the use of a customized filter.



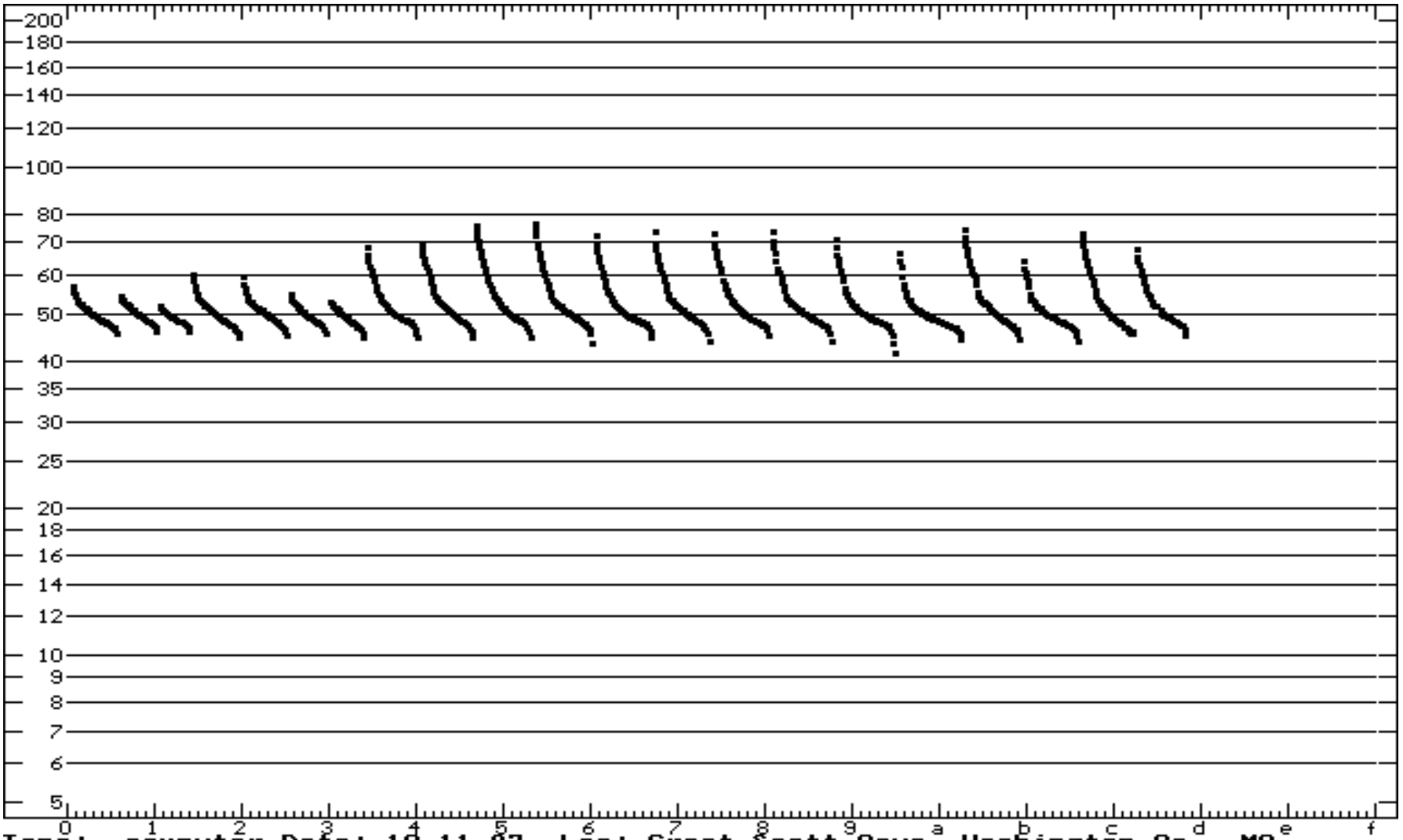
Tape: Rod1 Date: 8.7.99 Loc: Nantahala National Forest
Sp: E. fuscus Spec: free-flying
Note: recording at station in center of timber sale area

FUSCUS2.57# Div 16
TOT 150ms TK 10ms f7 COMP St 181 FILT clean
ANALOOK 4.6 May 1999



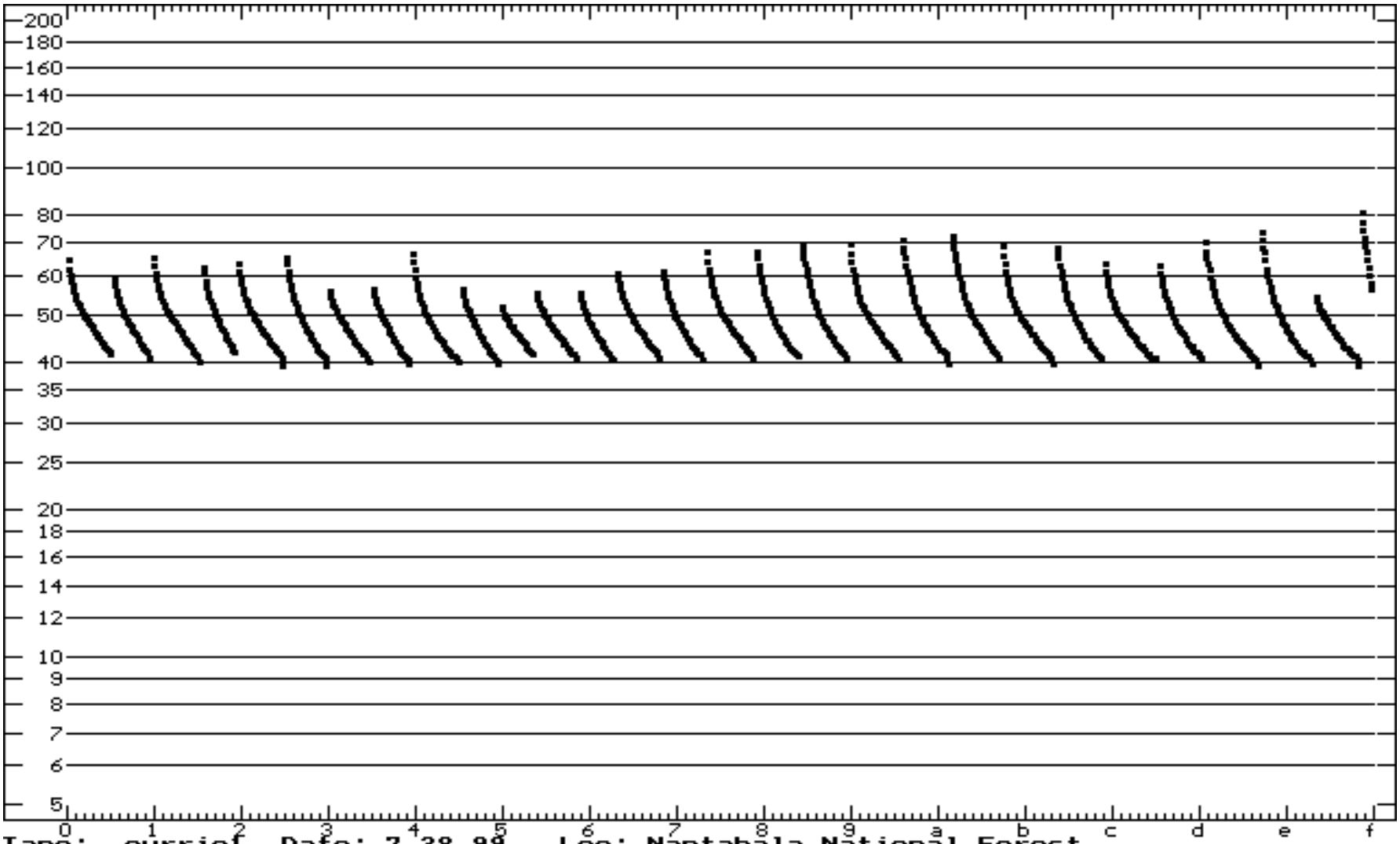
Tape: compaqf Date: 6.29.99 Loc: Cave Hollow Cave, Mo.
Sp: L. borealis Spec: free-flying
Note: flying along road 2369 near the cave

BOREAL~1.24# Div 16
TOT 150ms TK 10ms f7 COMP St 2 FILT clean
ANALOOK 4.6 May 1999



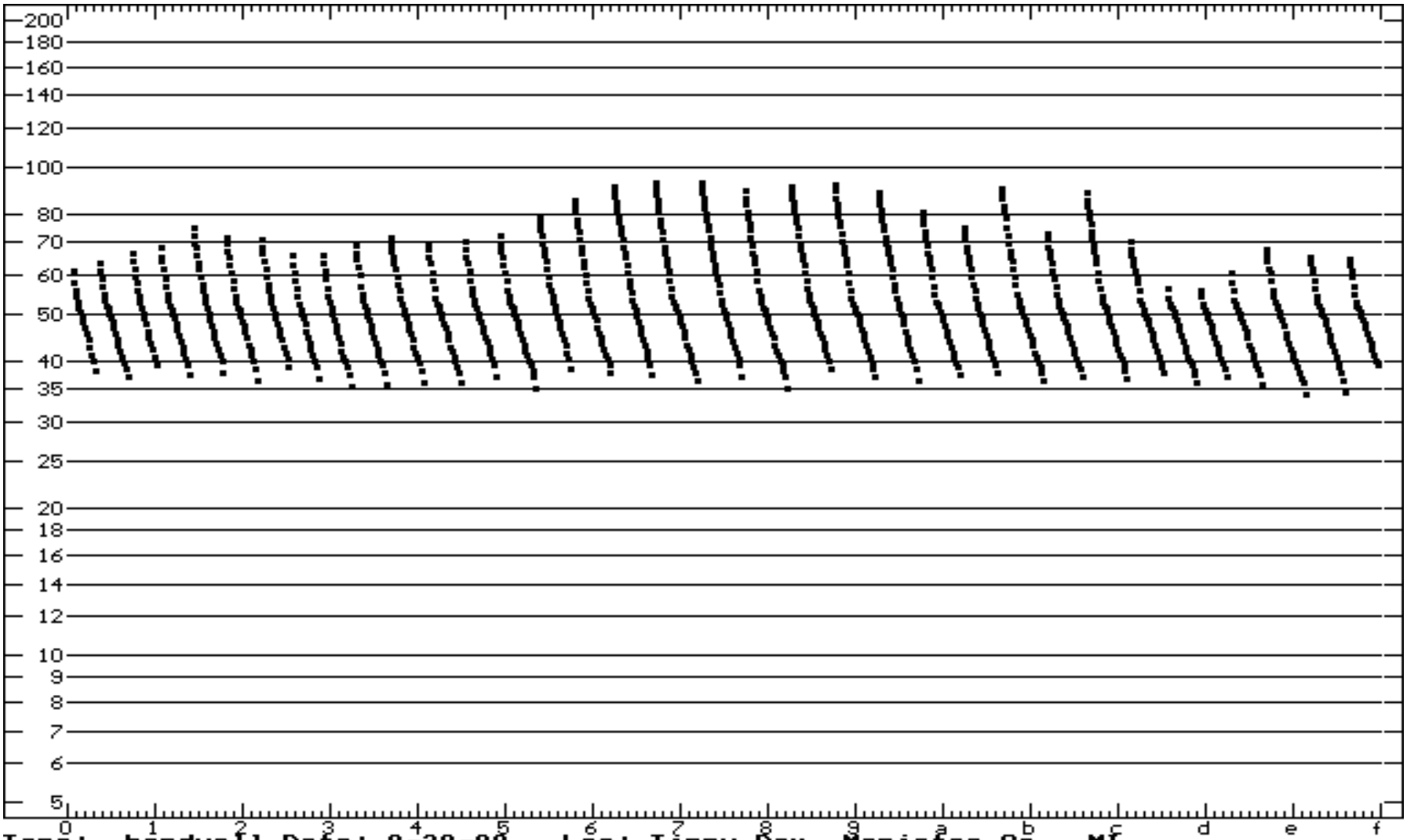
Tape: computer Date: 10.11.97 Loc: Great Scott Cave, Washington Co., MO
Sp: Myotis grisescens Spec: light tagged
Note: captured at cave entrance; released at Indian Creek bridge on Hwy. 185

7A112228.52# Div 16
TOT 150ms TK 10ms f7 COMP St 2 FILT clean
ANALOOK 4.6 May 1999



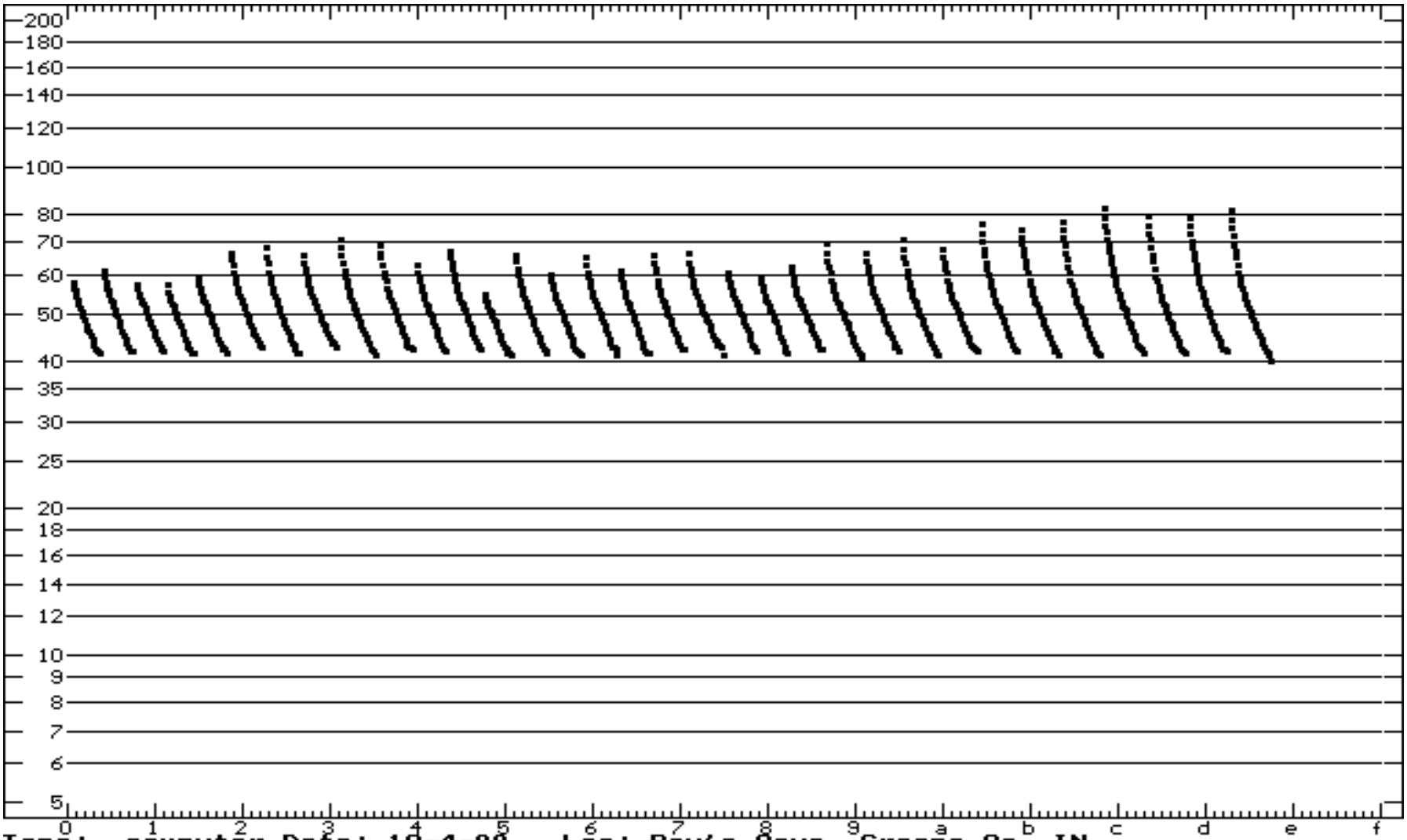
Tape: currief Date: 7.28.99 Loc: Nantahala National Forest
Sp: M. lucifugus Spec: passive
Note: recording at lower snowbird creek at 143 crossing

LUCI1.34# Div 16
TOT 150ms TK 10ms f7 COMP St 190 FILT clean
ANALOOK 4.6 May 1999



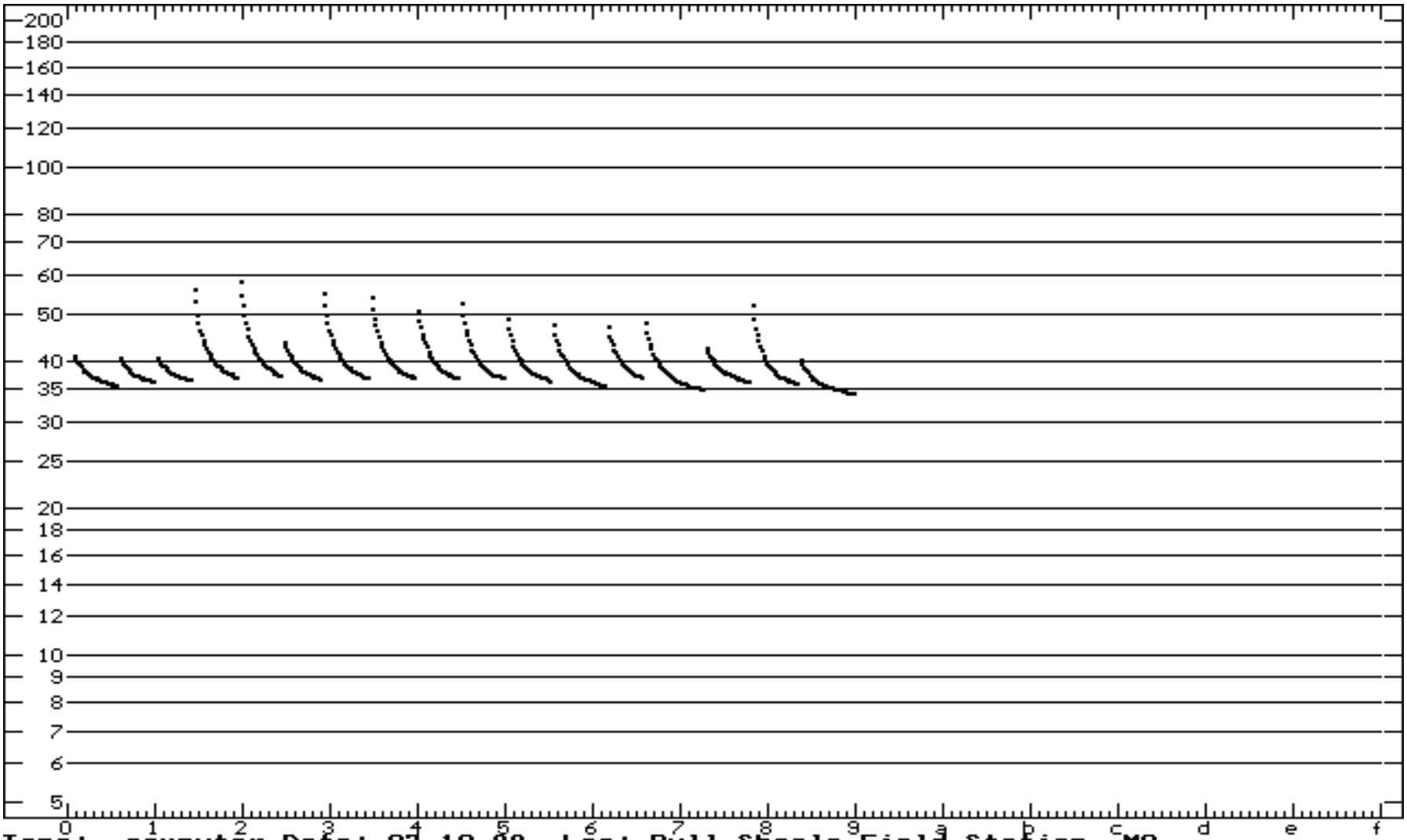
Tape: bondwell Date: 8-28-99 Loc: Tippy Dam, Manistee Co., MI
Sp: M. septentrionalis Spec: 22
Note: light tagged and released

SEPT2.08# Div 16
TOT 150ms TK 10ms f7 COMP St 2 FILT clean
ANALOOK 4.6 May 1999



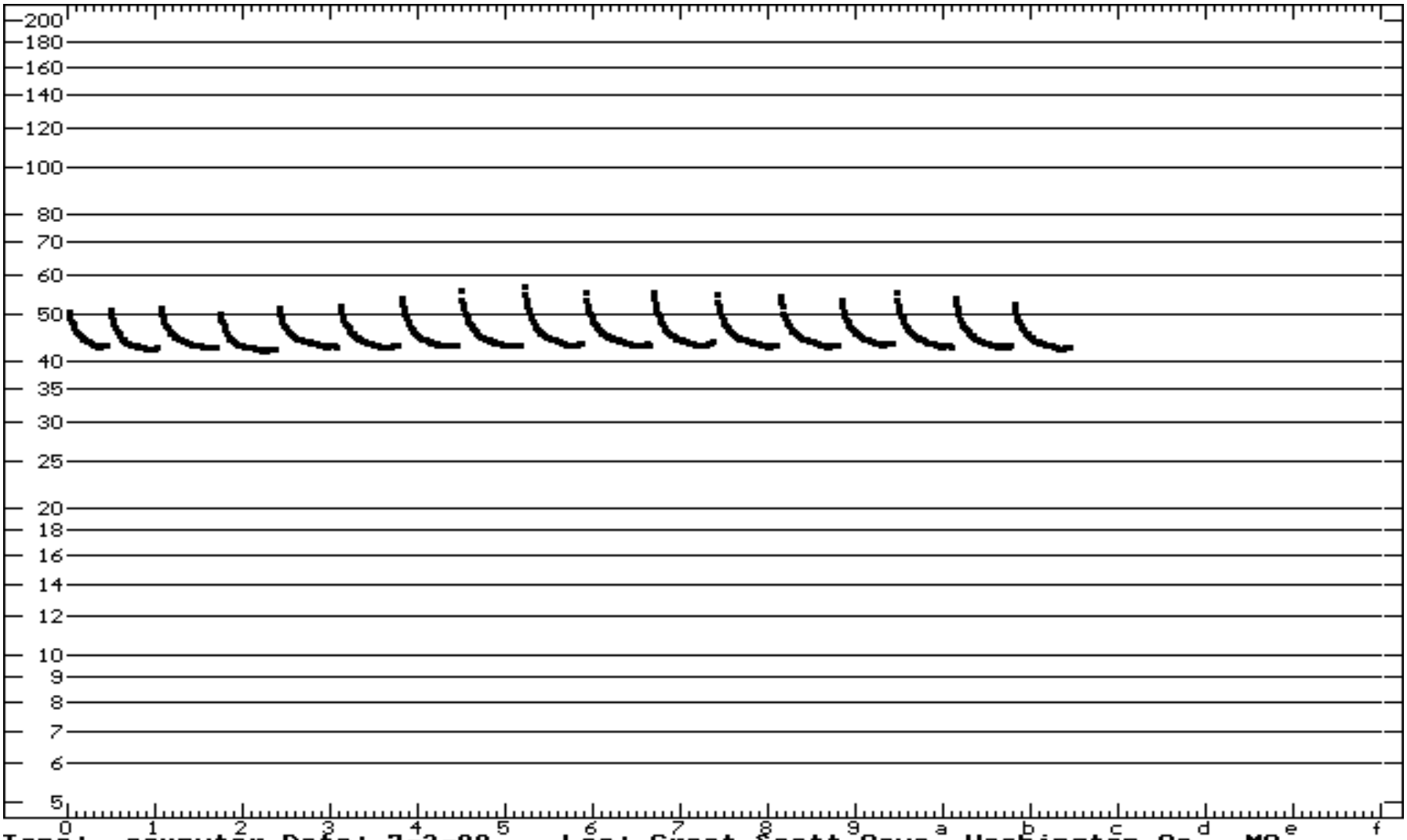
Tape: computer Date: 10-4-98 Loc: Ray's Cave, Greene Co. IN
Sp: M. sodalis Spec: bat # 11
Note: open field, hand release

SOD1.29# Div 16
TOT 150ms TK 10ms f7 COMP St 2 FILT clean
ANALOOK 4.6 May 1999



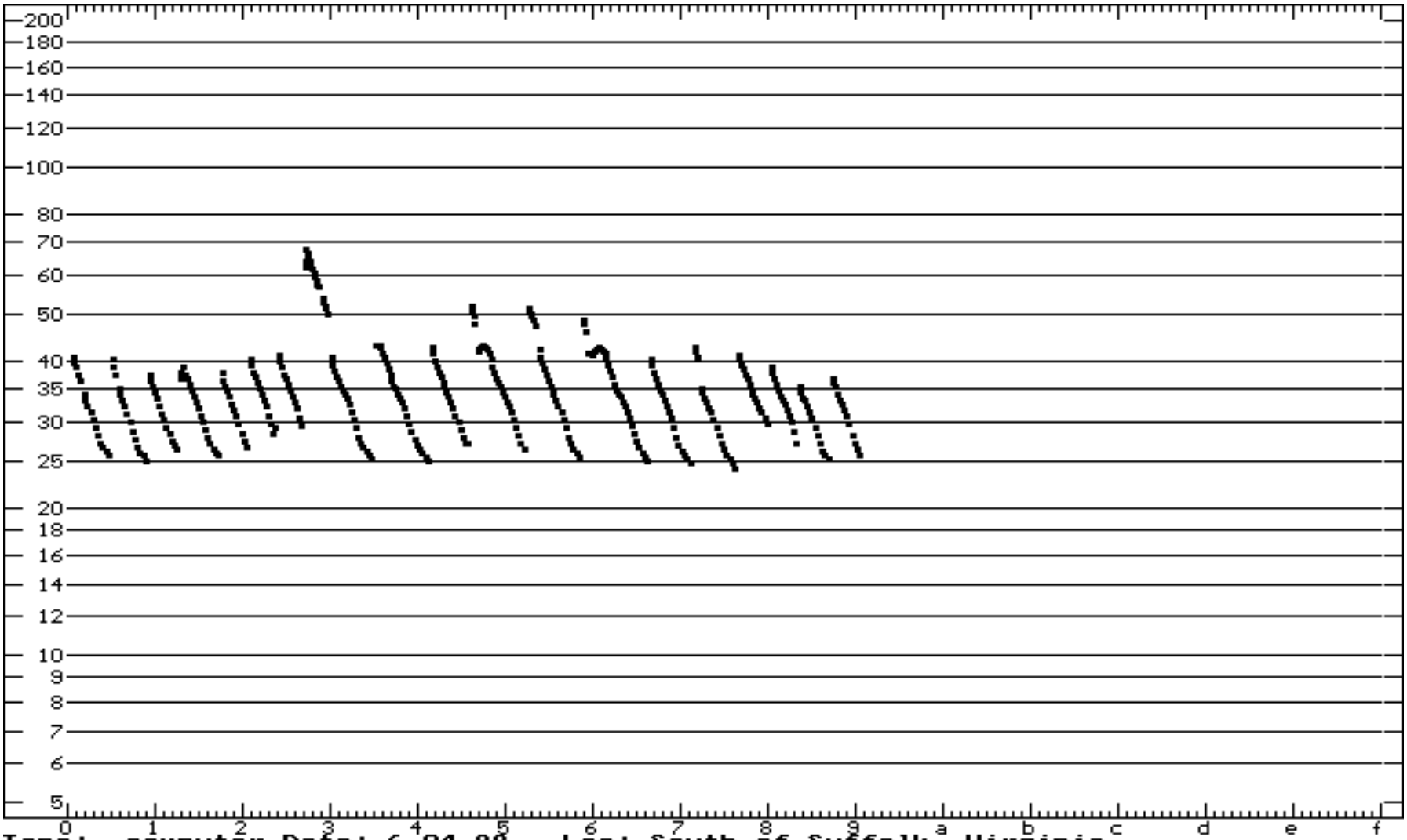
Tape: computer Date: 07.10.99 Loc: Bull Shoals Field Station, MO
Sp: N. humeralis Spec: light tagged
Note: released in field near station

97110053.23# Div 16
TOT 150ms TK 10ms f7 COMP St 2 FILT clean
ANALOOK 4.6 May 1999

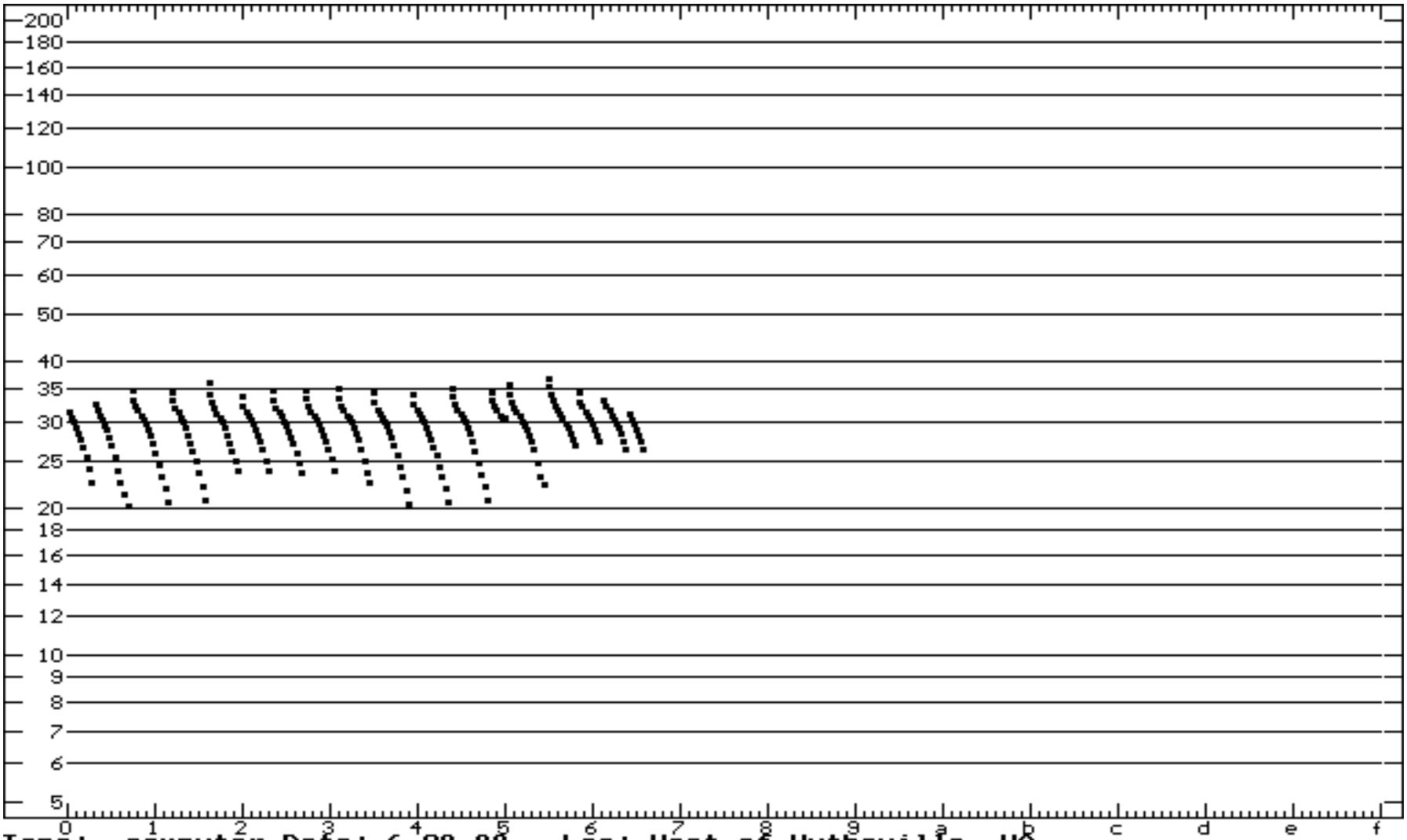


Tape: computer Date: 7-2-98 Loc: Great Scott Cave, Washington Co., MO
Sp: P. subflavus Spec:
Note: light tagged and released at the Bridge over Indian Creek on Hwy. 185

PIP2.57# Div 16
TOT 150ms TK 10ms f7 COMP St 600 FILT clean
ANALOOK 4.6 May 1999



Tape: computer Date: 6.04.98 Loc: South of Suffolk, Virginia
Sp: Corynorhinus rafinesquii Spec: light tagged
Note: recorded as females left a maternity colony;
with Don Schwab (Virginia Game and Inland Fish Commission)
86042139.40# Div 16
TOT 150ms TK 10ms f7 COMP St 1240 FILT 0
ANALOOK 4.6 May 1999



Tape: computer Date: 6.08.98 Loc: West of Wytheville, VA
Sp: Corynorhinus townsendii Spec: light tagged
Note: captured at cave entrance; released in open field;
with Rick Reynolds (Virginia Game and Inland Fish Commission)
86082149.28# Div 16
TOT 150ms TK 10ms f7 COMP St 176 FILT 0
ANALOOK 4.6 May 1999