Z. Säugetierkunde 53 (1988) 65–68

ISSN 0044-3468

Sonar used by flying Lesser horseshoe bats, *Rhinolophus hipposideros* (Bechstein, 1800) (Rhinolophidae, Chiroptera), in hunting habitats

By I. Ahlén

Department of Wildlife Ecology, Swedish University of Agricultural Sciences, Uppsala

Receipt of Ms. 21. 1. 1987

Abstract

Flying lesser horseshoe bats were recorded in their natural hunting habitats at a number of different localities in Spain. The common sonar pulse consisted of about a 50 ms long CF-signal with a short upward sweep at the start and a downward sweep at the end. The CF-portion of the pulse had its strongest component at about 110 kHz. This is the second harmonic while there is a weaker first harmonic at about 55 kHz. The pulses were repeated about ten times per second. The material did not show much variation which suggests that the auditory system is sharply tuned to the optimal frequency and that the local populations do not show much acoustic variation. One observation indicated that the lesser horseshoe bat might hunt from a perch like a flycatcher.

Introduction

Since the studies of ultrasonic emissions of the lesser horseshoe bat by Kay and Pickvance (1963) the sonar of this species has been known only in general terms. Good sonar data from hunting situations in natural habitats have not been published. From other species we know that there may be important differences between sonar used indoors and outdoors; in outdoor flight the pulses are more developed in shape and specificity than in indoor flight (Ahlén 1981). Is the small variation in frequency described by Kay and Pickvance (1963) for bats flying indoors still valid in a variety of natural field situations? Lesser horseshoe bats are considered to have the highest frequency of all European bats, but are the constant frequency signals pure tones or are there harmonics?

Material and methods

The ultrasonic sonar emitted by lesser horseshoe bats, *Rhinolophus hipposideros* was recorded on a number of different geographical localities in Spain 1982, 1985 and 1986. The bats were recorded when found in the hunting habitats in the surroundings of their roosts. The recordings were 1982 made with a prototype to the D-920 frequency dividing detector (Ahlén et al. 1984) and a cassette recorder. In 1985 recordings were made with a further developed version of the same detector, called D-940. In addition to using cassette recorders, high frequency signals were also recorded with a Racal Store 4 D instrumentation tape recorder. In 1986 most recordings were done with the detector version D-960 which contains a 'time expansion' unit (signals stored in a digital memory and read to the recorder in one tenth of the original speed) (Pettersson 1986). In 1986 visual observations were made with the aid of an image amplifier, Wild Heerbrugg Big2.

Analyses were made of a selection of recordings from Sevilla (Andalusia), Leon (Leon), Oviedo (Asturias), Huesca (Aragon) and Barcelona (Catalonia) provinces (regions) of Spain. The signals were inspected and measured by the use of a digital memory oscilloscope, an FFT-analyser and by making sonagrams.

U.S. Copyright Clearance Center Code Statement: 0044-3468/88/5302-0065 $ 02.50/0

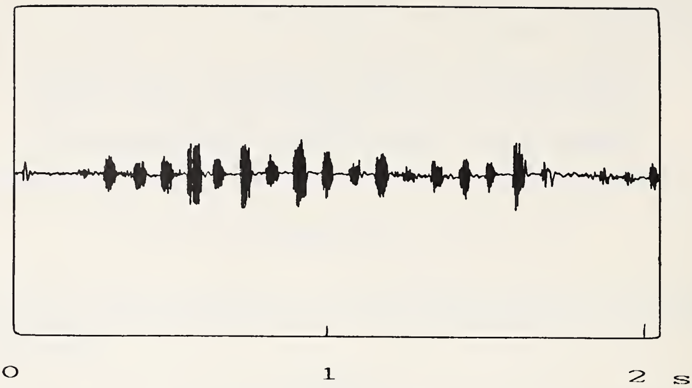

Fig. 1. A pulse train from a lesser horseshoe bat *Rh. hipposideros* flying past the observer shown as an oscillogram (relative amplitude against time)

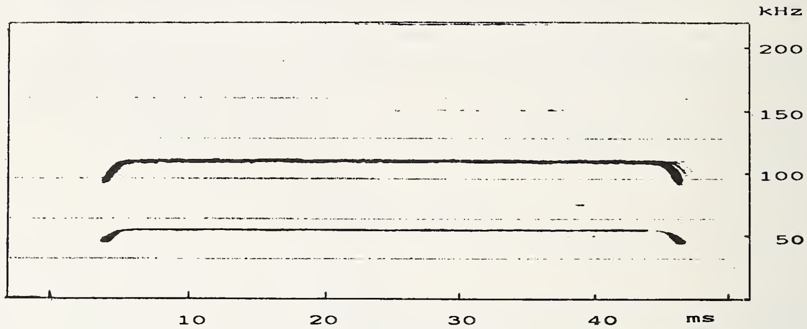

Fig. 2. A single sonar pulse shown as a sonagram with frequency against time. A weak first harmonic at 54 kHz and a strong second harmonic at 108 kHz

Results

The lesser horseshoe bats were found hunting along hillsides or steep cliffs, in small open spaces in scrubland and along low tree galleries at the edge of streams and ponds. Flying bats were also observed along walls of big buildings and stonedikes. Its sonar could only be heard at a short distance, with the D-940 (and D-960) only about 10 meters or even less. The most common sonar type used in these environments had remarkably small variation and was easy to distinguish from the two other *Rhinolophus* species (*ferrum-equinum* and *euryale*) occuring in the same areas. The sonar signals consisted of a fast pulse train with about 50 ms long pulses (40–69 ms, average 48 ms, n = 21) repeated regularly with a little less than 100 ms between the start of each pulse (64–99 ms, average 89 ms, n = 19) (Fig. 1). Each pulse consisted of a long constant frequency signal with the strongest component at about 110 kHz (106–111, average 109 kHz, n = 23), a short upward sweep at the start and a corresponding downward sweep at the end stopping at about 90 kHz. The analyses revealed that there is a weaker first harmonic at about 55 kHz, which means that it is the second harmonic which has the most energy (Figs. 2–3). After this discovery I have noticed that the fundamental is easily heard in the field by tuning the heterodyning to 55 kHz. Some analysed pulses also showed a faint third harmonic at about 165 kHz (Fig. 3).

The occurrence of weak fundamentals together with strong second harmonics have been

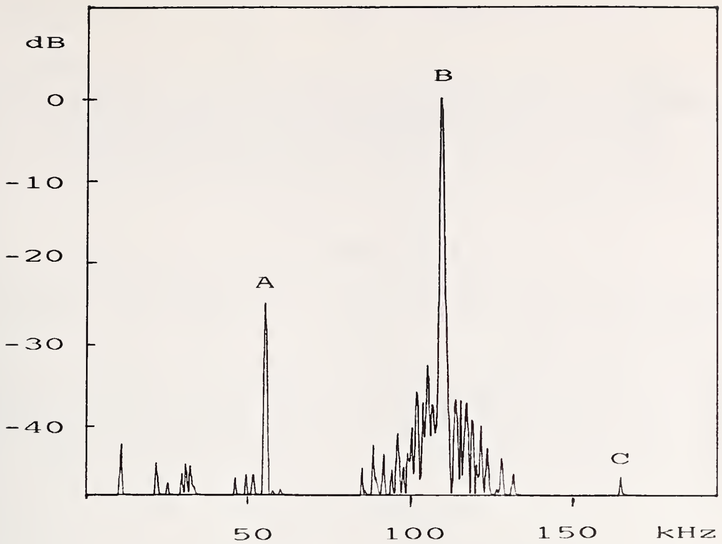

Fig. 3. FFT-analysis (Fast Fourier Transform, with Hanning weighting) of a CF-part of a pulse showing a maximum sound pressure at 110 kHz for the second harmonic (B), a weaker peak at 55 kHz (−42 dB relative to B) for the fundamental (A) and a third harmonic at 165 kHz (C) (−46 dB relative to B)

discussed e.g. by Sales and Pye (1974, p. 58) and was described for *Pteronotus parnellii* (Suga 1984).

The lesser horseshoe bats were also using other sounds at times, especially when they were circling around the entrance to their roosts or when they were hanging on twigs or small rocky outcrops. In the latter cases the differences mainly consisted of a varied pulse length and repetition rate. My material is still insufficient to give a detailed description of these sound types.

At one occasion I made an observation suggesting that *Rh. hipposideros* can use the ‘flycatcher’ behaviour described in tropical *Rhinolophus* species (Schnitzler et al. 1985). A lesser horseshoe bat was observed hanging on a small rocky outcrop. After a while it flew away out in the vegetation. I could hear it fly around but lost contact with it very soon. Coming back to the rock a couple of minutes later, I found the bat hanging on exactly the same place again.

Discussion

Bats with CF-components can separate their frequencies individually and thus might avoid interference (Miller and Degn 1981). They are likely to return to their optimal frequencies when hunting alone. Rhinolophid bats can compensate for doppler shifts to keep echo within a narrow band of best auditory frequencies (Schnitzler and Henson 1979; Sales and Pye 1974).

The ultrasonic sounds used by *Rhinolophus hipposideros* in a summer nursery colony (indoors) were studied in England by Kay and Pickvance (1963). They reported that the female bats had a very small range of frequencies, only 3 kHz, from 110–114 kHz. The small range of frequencies seems surprising since about 60 bats were present. K.-G. Heller (pers. com.) recorded hand-held specimens of five *Rhinolophus*-species where *Rh.*

hipposideros of various origin (Southern Germany and Greece) ranged from 105 to 111 kHz.

When comparing the same bat species from a number of geographically different localities it could not be excluded that there is a greater variation in frequency. Therefore it is noteworthy that even my data on *Rh. hipposideros* from a number of colonies in different parts of Spain did not show much variation. This suggests that the auditory system is sharply tuned to the optimal frequency of the species and that the local populations do not show much acoustic variation.

Acknowledgements

This study was made possible in 1982 in connection with a study travel financed by the Swedish National Environmental Protection Board, in 1985 with the Spanish state's grants for scientific cooperation between Spain and Sweden and in 1986 with economical support from the Swedish University of Agricultural Sciences.

I thank Dr. L. Miller, Odense, for valuable suggestions when analysing the material and preparing an earlier draft of this article. I also thank Dr. H. Baagøe, Copenhagen, for cooperation in the field work and for critical comments on the manuscript. Finally I thank Dr. K.-G. Heller, Erlangen-Nürnberg, for kindly providing me with results from his sound recordings.

Zusammenfassung

Ortungslaute von fliegenden Kleinen Hufeisennasen, Rhinolophus hipposideros (Bechstein, 1800) (Rhinolophidae, Chiroptera), in Jagdbiotopen

Laute der fliegenden Kleinen Hufeisennasen wurden mit Tonbandgerät in natürlichen Jagdbiotopen in vielen Lokalitäten in Spanien aufgenommen. Der gewöhnlichste Ortungslaut besteht aus einem etwa 50 Millisekunden langen konstantfrequenten Signal mit einem kurzen frequenzmodulierten Anfangs- und Endteil. Der Konstantfrequenzteil hat die stärkste Komponente mit etwa 110 kHz. Das ist der erste Oberton, während der Grundton bei 55 kHz schwächer ist. Die Laute werden etwa zehnmal pro Sekunde ausgesendet. Die Variation an Ortungslauten zwischen Individuen und Populationen war sehr klein, wahrscheinlich ein Ausdruck für einen sehr engen reizbaren Frequenzbereich im Gehörorgan. Eine Observation deutet an, daß Kleine Hufeisennasen die Jagdtechnik der Fliegenschnäpper benutzen.

Literature

Ahlén, I. (1981): Identification of Scandinavian bats by their sounds. Sw. Univ. Agr. Sci., Dept. of Wildlife Ecology, Uppsala, Sweden, Rep. **6**, 1–56.

Ahlén, I.; Pettersson, L.; Svärdström, A. (1984): An instrument for detecting bat and insect sounds. Myotis **21–22**, 82–88.

Kay, L.; Pickvance, T. J. (1963): Ultrasonic emissions of the Lesser Horseshoe Bat *Rhinolophus hipposideros* (Bech.). Zool. Soc., London, Proc. **141**, 163–171.

Miller, L. A.; Degn, H. J. (1981): The acoustic behavior of four Vespertilionid bats studied in the field. J. Comp. Physiol. **142**, 67–74.

Pettersson, L. (1986): Instruments for detection and analysis of ultrasonic signals. Inst. Technology, Uppsala university. Rep. UPTEC 86126R.

Sales, G.; Pye, D. (1974): Ultrasonic communications by animals. London: Chapman and Hall.

Schnitzler, H.-U.; Hackbarth, H.; Heilmann, U.; Herbert, H. (1985): Echolocation behavior of rufous horseshoe bats hunting insects in the flycatcher-style. J. Comp. Physiol. A **157**, 39–46.

Schnitzler, H.-U.; Henson, O. W. (1980): Performance of airborne animal sonar systems: I. Microchiroptera. In: Animal Sonar Systems. Eds. R.-G. Busnel and J. F. Fish. New York and London: Plenum Press. pp. 109–181.

Suga, N. (1984): Neural mechanisms of complex-sound processing for echolocation. Trends NeuroSci. **7**, 20–27.

Author's address: Prof. Dr. Ingemar Ahlén, Department of Wildlife Ecology, Swedish University of Agricultural Sciences, Box 7002, S-75007 Uppsala, Sweden