Echolocation – seeing with sound

Bats have been finding their way in the dark and hunting prey at night for over 55 million years. But nobody understood how they did it until less than 70 years ago.

When we go out at night, although we have eyes, we cannot see well unless we use a torch. The beam of *light* from the torch shows us what is ahead. Bats, like us, have eyes that can see when it is light. But when they fly at night they send out pulses of sound which act as a torch of *sound* to give them a picture of what is in front of them. We call this system **echolocation** – locating, or finding things, by their echoes.

How do bats produce and hear these calls?

Bats make and hear sounds just as we do. They produce their echolocation calls by passing air over the vocal cords in their larynx, or voice box, so making them vibrate.

Most bat echolocation calls are so high-pitched we can only hear them by using a bat detector. Bats send out their calls either though their mouths or their nostrils.

Those using their nostrils, like the horseshoe bat, have strange folds of skin over their faces which help to focus the sound. Most bats in the Vesper family call through their mouth, which is why most photographs of flying bats show them with their mouths open.

Sound analysis

Computer software can generate an image, known as a sonogram, from the sound recorded on a detector. We can use the sonogram to look at the shape and characteristics of the call to help identify the species of bat. Once we have identified the bats we can label the sound files for further data analysis.

Social calls

Although the echolocation calls used by bats as they fly and feed are ultrasonic, above our level of hearing, they also make sounds which are audible to many people. As with so much of bat behaviour, there is a great deal we still don't understand about these social calls.

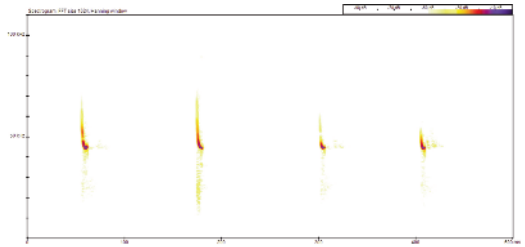
If you are lucky enough to know of a summer maternity roost of pipistrelles, and can stand outside at dusk, you will hear their excitable chatter just before they emerge. What's going on? Are they exchanging information on where they plan to hunt, or just excited about the supper they hope to catch? What do *you* think?

One of the most exciting parts of watching for bats, or going on a bat walk, is being able to *listen* to their calls using a bat detector. This changes the bats' ultrasonic calls to a frequency, or pitch, that we *can* hear.

Probably your parents and certainly your grandparents never had the opportunity to go out and listen to bats as you do. Until recently bat detectors small and inexpensive enough for most people were unavailable.

How do bat detectors work?

There are three different ways in which the incoming ultrasound can be transformed and there are advantages and disadvantages over each other. All still consist of the same main components: a microphone sensitive to very high frequencies, and the electronics to manage that sound, either to transform it to produce an audible sound for us to listen to, or to transfer it to a computer for analysis. Detectors can listen for a specific frequency (narrow band) or they can scan across all the frequencies (broadband).



Sonogram of a common pipistrelle call, showing the loudest part of the call at 45kHz

Bat detectors enable us to survey for bats even when none can be seen

Active surveys require you, the observer, to walk around perhaps along fixed routes or transects, or to stand outside a bat roost, to listen to the calls being made by bats and\or to record those calls for analysis afterwards.

Passive surveys involve leaving bat detectors in the "field" for a period of time (days or weeks) to record bat activity. The bat calls are recorded and saved onto a data card which is then analysed on computer. These are static point surveys. From this information, we can identify which bats are flying, when they are flying, and get an index of activity.

Echolocation – investigating sound

Sound is a form of energy

Noctule bat calls can be heard by some people, not because of their loudness but because their call has the lowest pitch of all our bats.

There are many ways of making sounds – banging, blowing, plucking – but all sounds are made by something moving, which in turn creates vibrations – pulses of energy that travel in waves.

The number of times that sound vibrates per second is called its frequency. This is measured in Hertz, named after a 19th century German scientist.

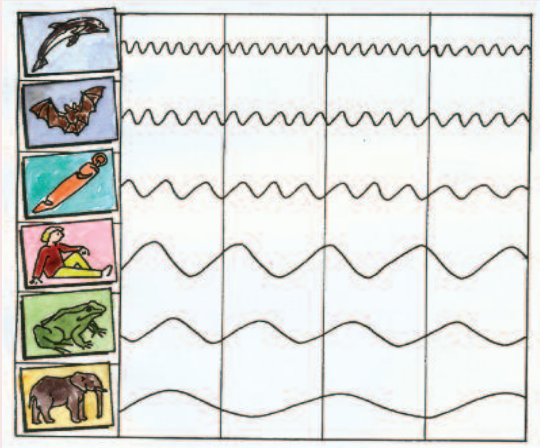
Very high sounds, like those produced by bats echolocating, are measured in kilohertz (kHz). One kHz is one thousand cycles per second. So the pitch of a sound is a measure of the frequency of the sound waves, the speed at which an object vibrates. When we are speaking the 'object' is our vocal cords.

Sounds audible to most people are those with frequencies between 20 and 20,000 (20Khz).

Infrasounds are sounds with frequencies ***below*** 20 hertz (20h). Elephants and whales produce infrasound which is capable of travelling over very long distances.

Ultrasounds are ***above*** 20,000 hertz and are not usually detected by humans. Bats and dolphins produce ultra sounds.

Sound moves in waves



High frequency sound has shorter wavelengths than low frequency sound. This diagram compares some sounds.

Dolphin sonar 200Hz

Bats' echolocation 25kHz-120kHz

Dog whistle 25kHz

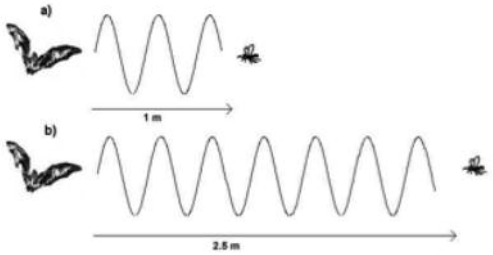
A person talking 150-500kHz

A frog croaking 120-200kHz

An elephant's lowest rumble 14-35kHz

Why do bats use such high frequency calls?

Bats use ultrasound for echolocation because of its short wavelengths. The higher the frequency, the more detailed the sound picture the bat can form.



Bats produce two types of sound. The first are social calls which are used for communication which can be within the audible range. Second are higher frequency echolocation calls that they use to find their way around the landscape and to find food. Although some people can hear part of these calls, they are not audible to most. With the help of a bat detector we can use these calls to help identify bats.

How loud are the sounds made by bats?

As with so many questions we ask about bats—it all depends on the species! The sound made by pipistrelle bats could be compared to a smoke alarm. Noctule bats have the loudest call amongst bats, carrying up to 500 metres, and can be compared to the loudness of a jet engine. The echolocation calls of long-eared bats are as quiet as a computer keyboard.

A **decibel** (dB) is the unit used to compare sound levels. It is named after Alexander Graham Bell who studied sound in great detail. Both his wife and mother were deaf and he experimented with hearing devices. He is most famous for his part in inventing the telephone, though he never allowed one in his study as he complained it interrupted his work. The faintest sounds people can hear are about 10 dB. Above about 130 dB noise can become painful to us.

Warning signs show that loud noises might damage your ears, causing permanent damage.