Lifting the cover of darkness

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It was about 10 years ago or so that I found myself wondering around my local Maplin electronics shop, looking at the many electronic gadgets on offer. I have always had a bit of a reputation for being a gadget geek. I guess that this is one of the reasons that I could never resist the temptation of walking past an electronic store. But on this occasion, I was on a mission.

A few evenings before, I was enjoying one of my favourite summer evening pastimes – watching bats flitting around the streetlamps, in pursuit of insects. This is something that I had done for as long as I could remember. However, this evening was depressingly different from the past years. Whereas before I could often hear some of the high-pitched calls of the bats, now I could not hear anything, no matter how hard I strained my ears.

I often walked along country lanes on summer evenings and would come to a stop as I tried to pinpoint the argumentative shrews that I could clearly hear in the undergrowth or the grasshoppers resuming their chirping as I stood motionless. And then it hit me; I was unable to hear the high frequencies of bats and shrews any longer. Despite my best efforts, the constraints of the ageing process had caught up with me!

Hence my reason for finding an excuse (any excuse if the truth be known) for finding myself browsing the wonders of the Maplin shop. Not entirely sure about what I was looking for, I was just about to exit the shop when I spotted a sign on a shelf that read "build your own bat detector". That's it, I was sold!

Not being very good with a soldering iron and flux but, somehow, I managed to build the DIY bat detector. I read the instructions countless times and practised my soldering skills before committing to attempt to add terminals and solder to the provided mother board. Finally, feeling a little smug with myself, I added the required batteries and, full of anticipation, switched on the bat detector for the first time and slowly rotated the adjustable frequency tuner. Within a few minutes I heard a sound that reminded me of large drops of 'plopping' water. I had detected my first bat on my homemade heterodyne bat detector.

Heterodyne detectors (Figure 1) are the easiest and certainly among the cheapest bat detector devices to purchase. Bats broadcast high frequency ultrasonic sounds at frequencies well beyond the detection rate of the human ear. A heterodyne detector converts the high frequency bat echolocation into a much lower frequency, slowing down the pulse rate so rendering it discernible to the human ear. It does this by subtracting the sum of the detected frequency from the bat ultrasonic call and playing that reduced frequency call back through the built-in speaker. As an example, the Common Pipistrelle will generally emit its echolocation calls at around 45kHz. If the heterodyne device is tuned into this range, then the onboard chip will subtract the sum of the frequency from the detected call (45kHz-45kHz). In theory this should result in no sound but, as bats never emit a precisely steady sound, so there will usually be some difference between the two signals resulting in an audible sound from the detector.

Figure 1. A typical heterodyne bat detecor.

Through practice and experimentation, it slowly dawned on me that it was also possible to dial into the sounds of insects such as grasshoppers and cricket stridulations, by tuning the detector dial to lower frequencies.

By using a simple device, such as a heterodyne detector, it is possible to begin lifting the cover of darkness. Once the sun sets during the spring and summer months, a whole new cast of mammals, birds, and insects begin to emerge.

As effective as they are in uncovering the presence of bats flying over during the hours of darkness, the inner geek in me was soon wanting to know more. Heterodyne detectors have limitations when it comes to trying to identify bats down to species levels.

There are 17 species of bat known to breed in the UK with an additional species represented by one single individual. All UK bat species employ ultrasonic echolocation calls to navigate around their environment during the hours of darkness and to detect and catch their prey. With several different species often hunting insects in the same area, each species has evolved its own unique ultrasonic echolocation call structure. Each species uses a different frequency range, bandwidth and pulse rate. Some of the differences between species are very subtle, especially among the Myotis species.

Here lies the limitations of a heterodyne detector. Such a device is not able to reveal or record such fine detail contained in a bat's echolocation vocal. With practice it is possible to identify a limited number of bat species such as Common and Soprano Pipistrelles with some degree of certainty but beyond that the level of certainty becomes very low.

To overcome some of these identification problems it is necessary to record and analyse the echolocation structure. This is best achieved by uploading recorded calls to desktop-based software where the full range and structure of calls can be examined in detail. Such recordings are known as Full Spectrum records. These files reveal the frequency ranges, the pulse rates and the call type/structure, Figures 2 and 3.

Heterodyne bat detectors are not capable of capturing such high-fidelity data. Even 10 years ago, such recording equipment would cost several thousands of pounds. Today, with the advent of smart phone technology

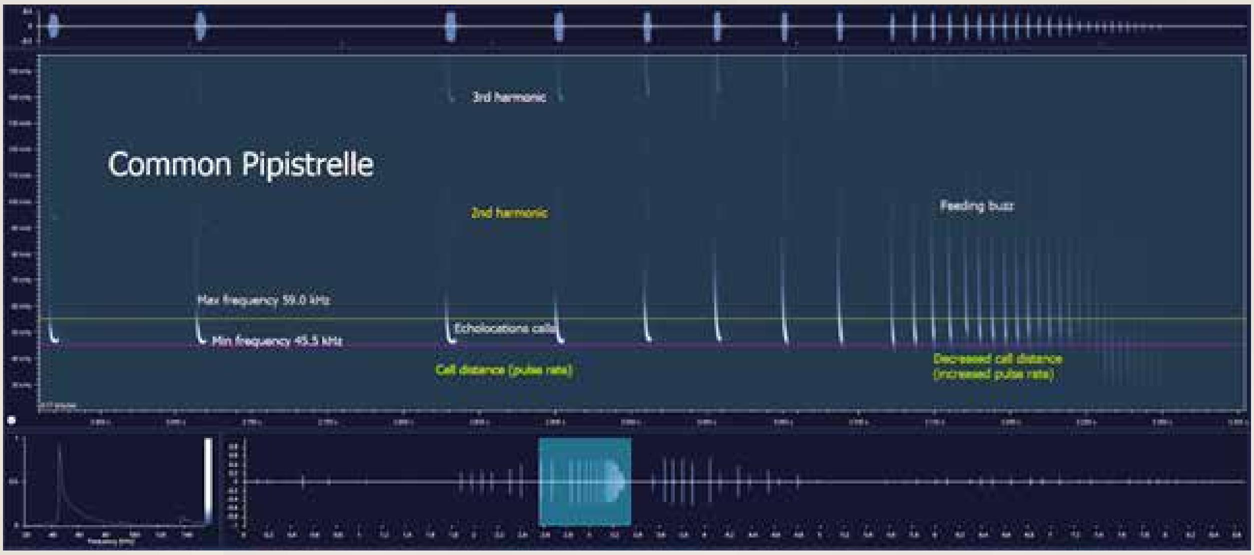

Figure 2. Sonogram showing the basic structure and features of bat echolocation calls.

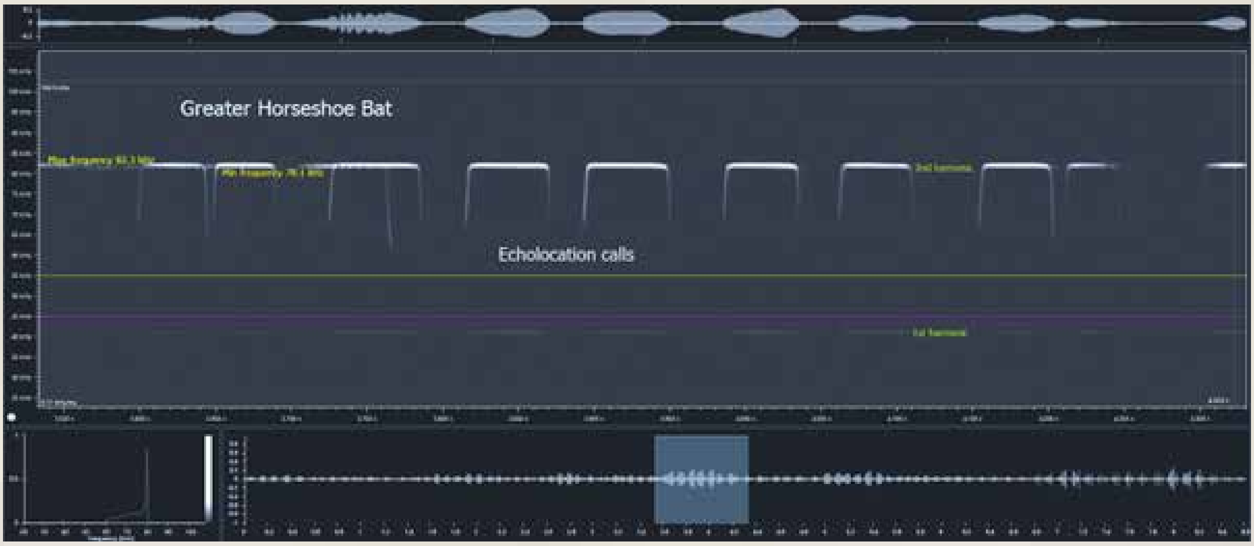

Figure 3. Greater Horseshoe Bat echolocation call structure.

and miniaturisation, recording devices are now available at greatly reduced costs. It is now possible to attach an ultrasonic microphone to a smart phone or tablet (Figure 4). The device not only detects the presence of bats in the immediate vicinity but, additionally, provides a full spectrum display showing a detailed spectrogram and oscillogram of the bat echolocation calls. Rather than depend on the familiar heterodyne sound, these devices are capable of time expansion sound. With the time expansion technique, the calls are recorded, and the file is displayed/played typically 10 times slower. The time-expanded sound is analysed in a computer program and the diagram (sonogram, spectrogram) can be stored as a picture-file. With this information, it is much easier to analyse and identify several of the more common bat species from the spectrogram.

Figure 4. Echo MeterTouch Pro attached to a tablet.

The smart phone modules help to begin to get a glimpse of the activities taking place in the immediate vicinity surrounding the user. However, there are several drawbacks to using these remarkable devices. The first being that, as these are real-time recording devices that display and play back the sound of the echolocations, it is very easy to become transfixed on the screen of the phone or tablet, especially if the 'autoID' function is activated. The problem is that much valuable information can be gained by observing the bat in flight, rather than watching the screen display. Not only can this be a useful way of helping to identify bat species, but it also helps to make a note of the environment which may modify the echolocation call structure.

Another disadvantage to consider is that some species such as the Large Brown-eared bat are gleaners rather than hawkers such as the pipistrelles. The gleaning species will often be very difficult to detect as they also depend on their acutely keen hearing to detect suitable prey, rather than returning echolocation during a large part of their hunting strategy. It is therefore possible for a Large Brown-eared bat to fly by within a few metres and not be detected by the microphone and only observed visually as it flies overhead.

Smart phone modules are great for real-time observations for a short period of time. To survey and record bat activity over a longer period of time; days or even weeks at a time, it is necessary to use a passive recorder, a device that can be left on location and unattended. They consume very little battery energy and are only triggered, and a recording activated, when a selected range of ultrasonic frequencies are detected by the unit. Such units give an insight to the level of activity in the area together with the number of different species that may arrive over a period of time. With additional benefits of inbuilt GPS mapping, flightpaths for each individual and each species can be recorded and displayed later during the analysis.

The cost of such units varies greatly with a small AudioMoth unit costing around £50-60 from Silicon Labs, to £800 - £1500 from some of the larger, established manufacturers such as Titley Scientific, Pettersson (Figure 5).

Figure 5. Typical Passive Acoustic Monitors (PAMS) – AudioMoth (top) with waterproof case and Anabat Chorus (below).

There are many software packages that can be used to analyse spectrograms of bat echolocation calls. Some of the more popular packages include SonoBat (www.sonobat.com), BatSound (www.batsound.com), Kaleidoscope (www.wildlifeacoustics.com). I use a combination of three software packages; AnaBat Insight (www.titley-scientific.com), BatExplorer (www.elekon.ch) and the totally free Audacity (www.audacityteam.org (Figures 6, 7 and 8).

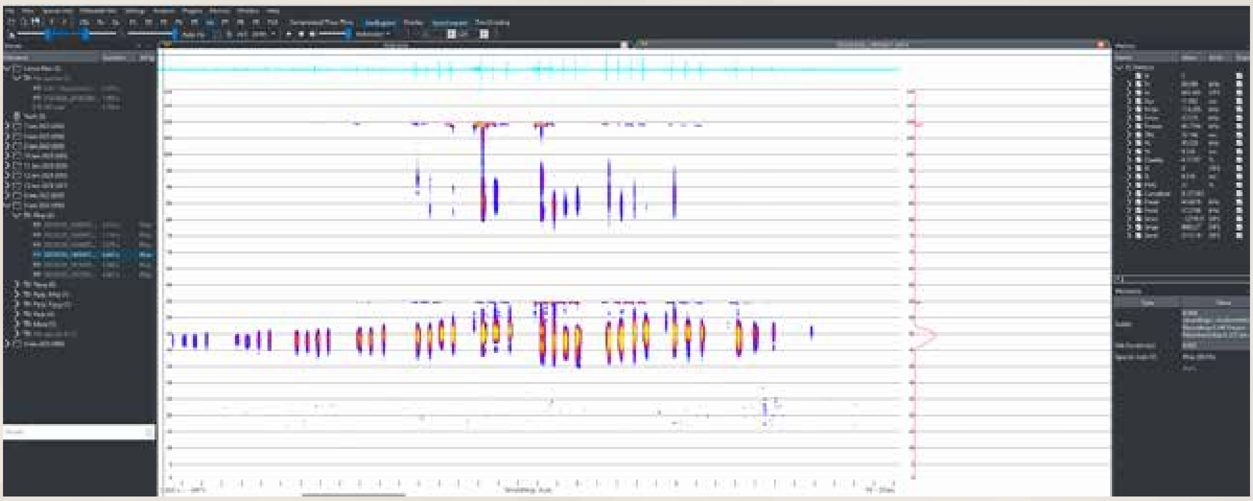

Figure 6. AnaBat Insight desktop interface.

Figure 7. Elekon BatExplorer desktop interface.

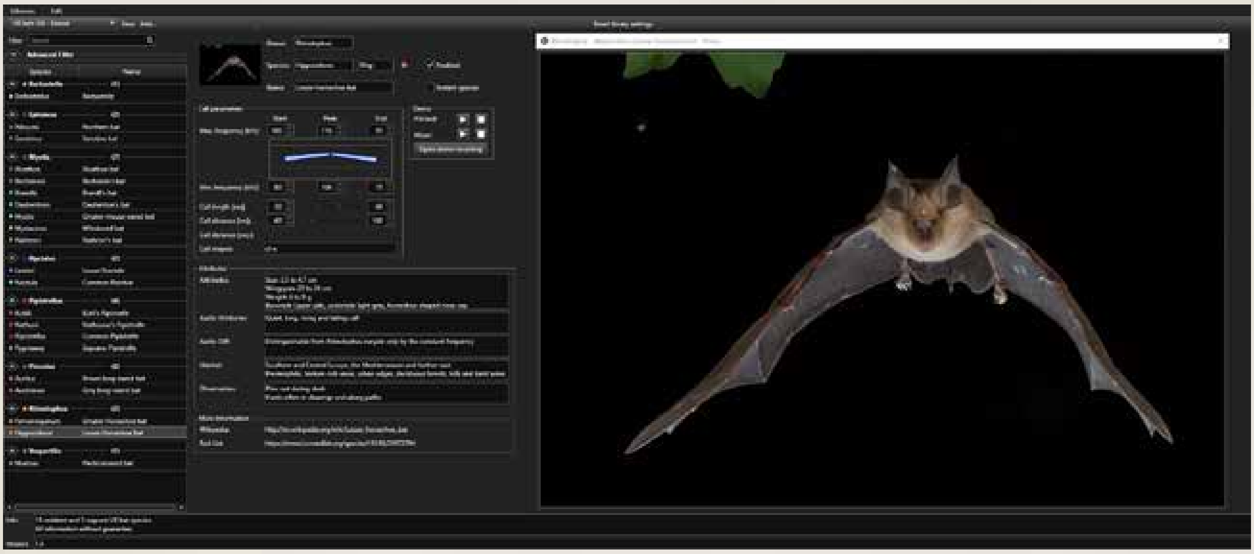

Figure 8. Elekon BatExplorer British & European bat library (included in the free version of the software).

Some programmes also provide auto identification classifiers down to bat species. To achieve this, the software employs algorithms to compare sonograms of recorded calls with those of known species (classifiers).

The signature echolocation calls of bats can vary greatly, even within the same species. Bats adjust their echolocation calls depending on the environment that they are flying in. The call structure will vary depending on whether the bat is flying in open areas such as fields or bodies of water, lines of hedgerows and woodland rides or in a cluttered environment such as a wood. Add to this the fact that bats also communicate with each other using complex social calls that are also ultrasonic by nature, it should come as no surprise to realise that is often difficult to identify bat species with any certainty based on recorded sonograms (Figure 9). AutoID classifiers should therefore be used with a great deal of caution and not as the only means of species identification.

The development of new devices ideally suited to detect and identify bats has helped to introduce more people to the largely hidden world of bats. There has been a significant increase in the amount of data that is now being collected by both professionals and, perhaps just as important, by increasing numbers of amateurs. This data is enabling conservation organisations such as the Bat Conservation Trust to build a much clearer picture of the population trends of many of the UK bat species. Despite this increased volume of data, there is still much that is unknown about our bat species. Access to affordable technologies will hopefully encourage more people to take an interest and help to increase our understanding of these largely enigmatic creatures.

Of course, bats are not the only creatures that emerge under the cover of darkness. Many insects are largely nocturnal as are small mammals such as voles and shrews. A surprising number of bird species also migrate during the hours of darkness and can often be detected on a passive acoustic recorder.

Bats feed on large numbers of insects during their nightly foraging. Of particular interest are, of course, moths. Research suggests that moths and bats have been engaged in ultrasonic warfare for millions of years. Bats evolved their echolocations to detect and capture insects, often on the wing. Many species of moths have evolved their own counter measure strategies to avoid falling prey to a marauding bat. Some will fall to the ground when detecting a bat in the area. Others have evolved stealth strategies by absorbing the echolocation pulses of a bat.

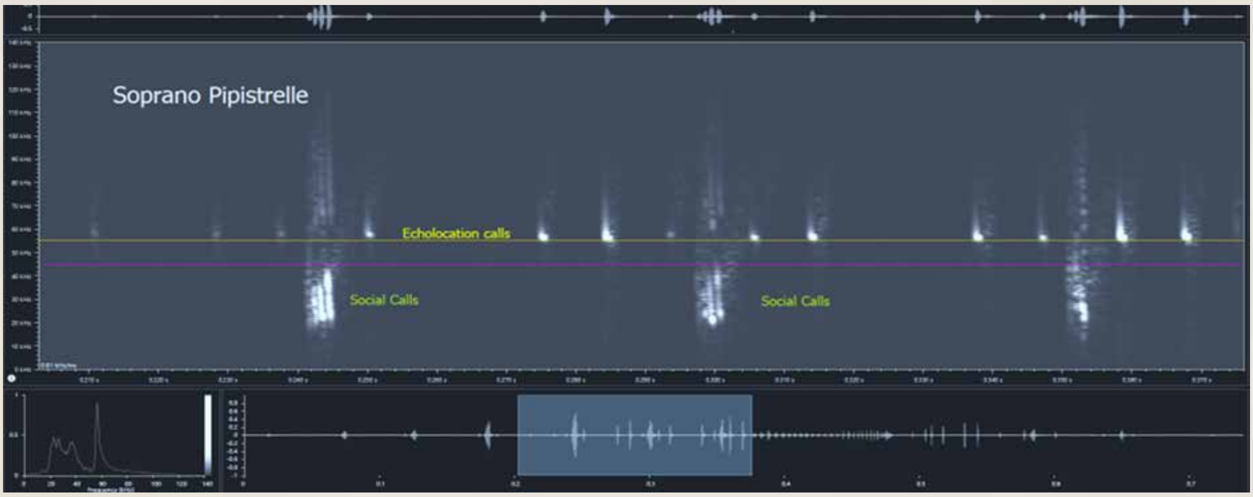

Figure 9. Echolocation calls and social calls of Soprano Pipistrelle.

Some 15, or so, species of moths found in the UK have evolved counter ultrasonic measures. They emit high frequency pulses that can either scramble and block the bat echolocation or, in some cases they are emitted in order to warn the bat of its presence. Such moth species are either toxic or unpalatable to bats. It has also emerged that some species of moths, very palatable to bats, are able to mimic the ultrasonic frequencies of the non-palatable moths in order to avoid falling prey to the hunting bat. Even more remarkable is that at least one species of the mimicking moths is totally deaf and yet has evolved to mimic the ultrasonic of another moth species.

During an average nightly recording session, many records will clearly not contain bat ultrasonics. Apart from moths and other insects, many small mammals also use ultrasonic calls to communicate with each other (Figures 10 and 11). A modern full spectrum bat detector is capable of detecting and recording such events. Even more complex than bat ultrasonics, much research work has been carried out to build libraries of mammal ultrasonic classifiers. A fine example of this is the British Trust of Ornithology (BTO) Acoustic Pipeline. After creating a free account, it is possible to upload full spectrum .wav files to the BTO server to be analysed by leading edge classifiers. After a short period of processing time, the system will generate a downloadable, detailed Excel spreadsheet which will highlight all bat, insect and mammal species together with the degree of certainty from the decision tree. Oddly enough, the BTO Acoustic Pipeline will not identify any records of birds other than an enigmatic classification of “Bird”.

There is no denying that with the continued pace of computing technology, especially in the field of machine learning, it is possible that even a casual foray with a bat detector on a summer’s evening can reveal a rich source of useful data. Potential gold nuggets for conservation bodies.

Whilst there are undoubtedly some concerns around the validity and robustness of the identification of species, such technology has helped to provide the informed individual with the ability to begin to understand much more of what takes place around us, under the curtain of darkness.

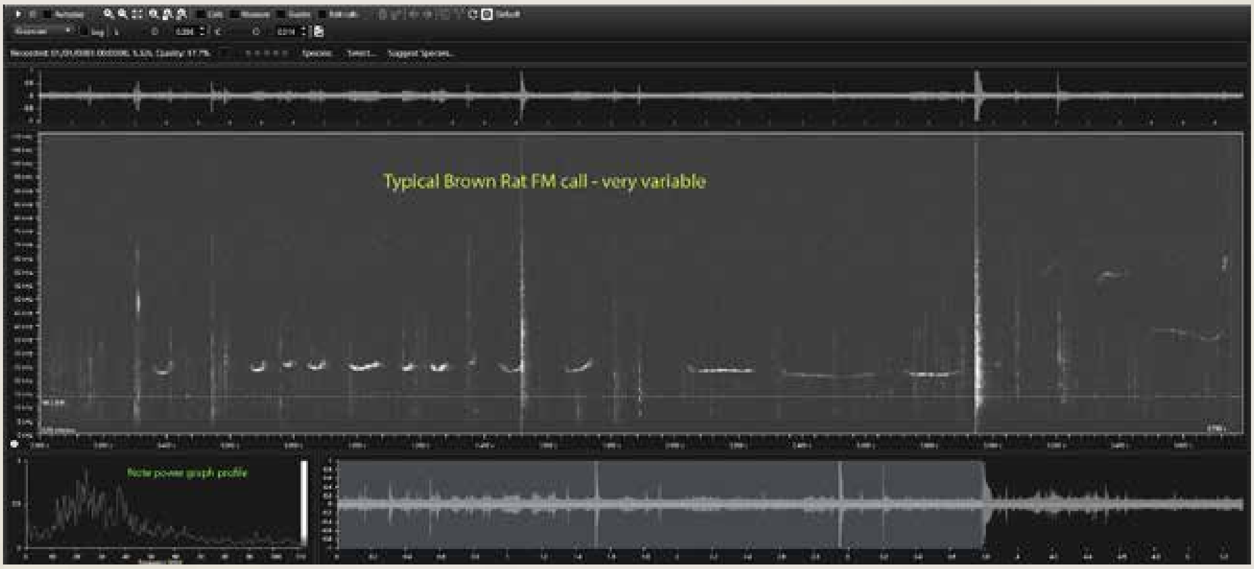

Figure 10. Typical Brown Rat FM call.

Figure 11. Typical Wood Mouse FM call.

Abia sericea in Wyre, 2022

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