Bats and whales behave in surprisingly similar ways

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A bat (*Myotis nattereri*) catches a worm, hung up by the scientists at University of Southern Denmark for it to find. Credit: Lasse Jakobsen/SDU.

Sperm whales weigh up to 50 tons, and the smallest bat barely reaches a gram. Nevertheless, the two species share the same success story: They both have developed the ability to use echolocation - a biological sonar - for hunting. Now Danish researchers show that the biosonar of toothed whales and bats share surprisingly many similarities - even though they

live in very different environments and vary extremely in size.

Echolocation systems are one of Nature's extremely successful specializations. About 1,100 species of bats and roughly 80 species of toothed whales use the technique – this is 25% of all living species of mammals. But why have such different animals as whales and bats both developed the same technique? The reason cannot be found in kinship, as bats and whales are no closer related to each other than all other mammals descended from the same land vertebrates for 200 million years ago.

The answer lies in convergent evolution – when almost identical features or developments happen in different species. Through evolution both bats and toothed whales have developed the same functional characteristics.

Researchers from the two Danish universities, Aarhus University and University of Southern Denmark, have now studied the acoustic properties of the technique behind echolocation in bats and whales in the wild. Previous studies of their abilities to locate and catch prey have primarily been based on laboratory tests, and the studies in the wild now provide a much more realistic picture of how the animals use echolocation. The studies have been published in the scientific magazine *Physiology* entitled "Functional Convergence in Bat and Toothed Whale Biosonars". The authors of the study are Professor Peter Teglberg Madsen from Aarhus University and Professor Annemarie Surlykke from University of Southern Denmark.

Pilot whale. Credit: Frants Jensen

"Our studies have shown that the sounds of bats and toothed whales are surprisingly similar. This is due to two things: First, all mammalian ears are developed in quite similar ways, and second, - which is the most surprising – the contradicting physical conditions in air and water along with the differences in size of the animals even out the differences, that you would expect in the sound frequency", says Professor Annemarie Surlykke from University of Southern Denmark.

As a bat is much smaller than a whale and its prey is accordingly smaller, it needs to produce sounds with a very high frequency in order to achieve the same capacity to determine direction and size of its prey. However, the effect of the higher frequency will be partially cancelled out by the fact that the sound is transported five times as slowly and that the sound waves therefore are five times as short in air as in water.

The researchers conclude that bats and toothed whales produce signals for echolocation in the same frequency range, from 10 to 200 kHz.

The advantage of operating in water rather than air is that the whale's "acoustic field of vision" is up to six times larger than the bat's. The "acoustic field of vision" is the area where the animal can "see" their surroundings using echolocation. A sperm whale can echolocate prey up to 500 meters away, while a bat's echolocation distance is only 2-10 meters.

Bats fly fast and cover approx. one echolocation distance per second. Therefore they often spend less than a second on detecting and catching their prey. Whales move more slowly and have a much greater echolocation distance. Thus they have more time to pick up information from the echoes and they have time to select their prey more carefully. This may explain why bats do not seem to be particularly picky with their prey, while toothed whales are much more selective about their food. The bat simply does not have the time to choose - it goes for fast food!

In the last part of the hunting phase, when they approach their prey both toothed whales and bats emit a series of buzzing sounds: Weak and short sound pulses at very short intervals – similar to strobe lights. It is a very complex mechanism that scientists do not yet fully understand. The animals control very carefully when they emit sounds and when they listen for echoes – and they adjust this exactly to their own and the prey's speed. If they emit the buzzing sounds too fast they do not have time to listen for the echoes. If they do it too slowly they risk hitting obstacles on the fly.

"The mechanism must play a key role but we do not yet know exactly which one," says Professor Peter Teglberg from Aarhus University and continues: "There is a need for further studies and fortunately new

technologies make it possible to track animals in the wild, study their behavior and compare these results with the knowledge we have from the laboratory".

Provided by University of Southern Denmark