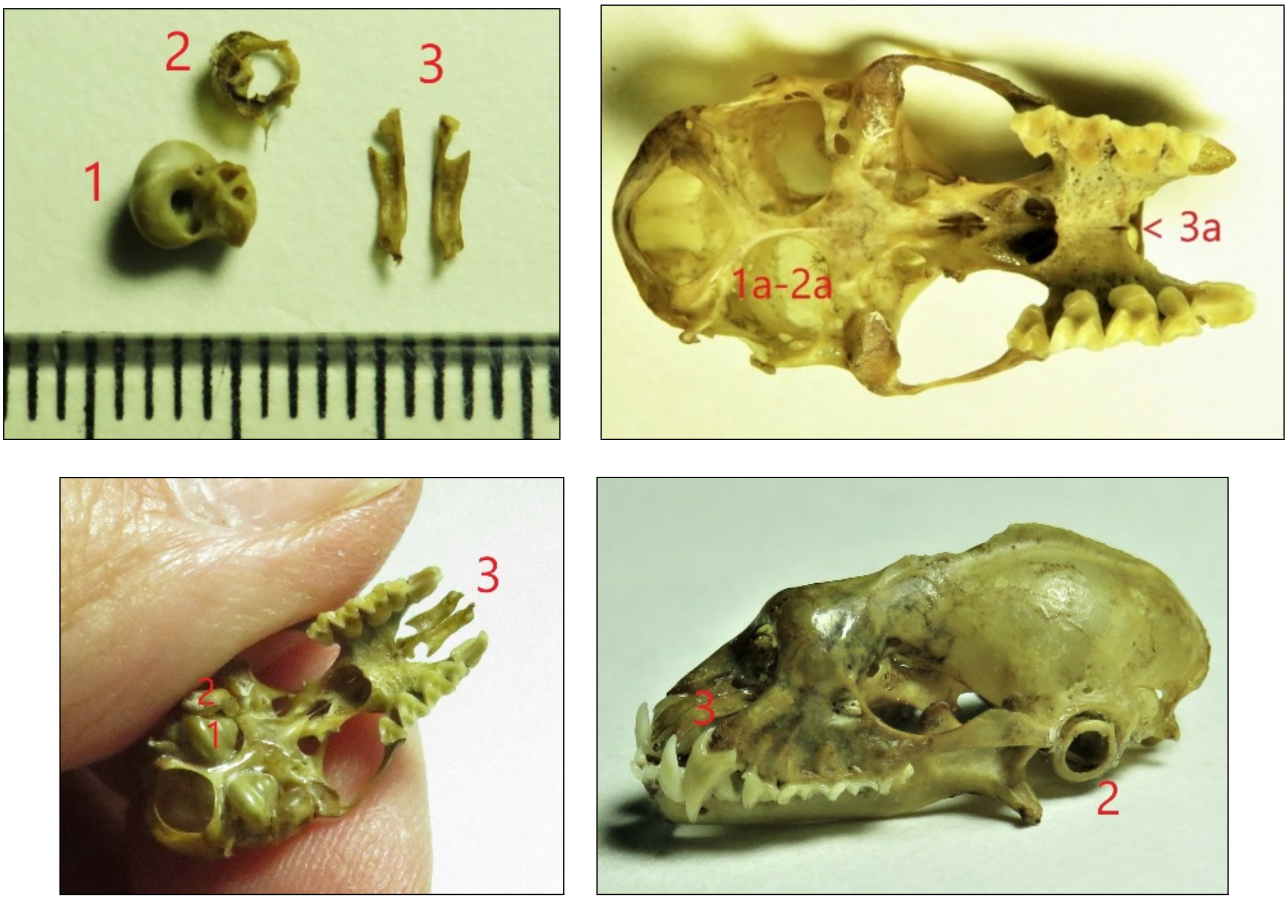
Small or Nothing

Trials of a bat skull enthusiast

The skulls of British bats are small. The bones which house the middle and inner ear (ectotympanic and petrosal bones respectively) are not firmly fused to the rest of the skull in bats as they are in other mammals but attached with soft connecting tissue. This means that they are often lost when flesh rots away after death. In the summer 2021 issue of this newsletter I admitted that I had not mastered the ability to glue them in place even if they were not lost. I am happy to say that since then I have gained that ability! It is still, however, very tricky because, since the skulls are small, the ear bones are *very* small. With horseshoe bats there is another problem. Unlike most other mammals, including other bats, the premaxillae (bones which hold the upper incisors) are not fused to the maxillae (which hold the other upper teeth) but are long and thin and attach to the maxillae only at one end. Old age doesn't help – my eyes are not as sharp and my hands not as steady as when I was young! Apart from anything else, getting a drop of glue that's not so big that it swamps the whole bone is difficult. The only saving grace is that any excess glue and careless placing can only be seen through the binocular microscope – but *I* still know if I made a bodged job.



Greater horseshoe bat skull (from a long dead bat found in a Dorset cave by Colin Morris):
1 petrosal bone, 2 ectotympanic bone, 3 premaxillae, 1a2a hole at bottom of brain case for petrosal and ectotympanic bones, 3a point of attachment of premaxillae, scale mm

It would be easier if the skulls and their loose bits were bigger – but it seems that could never be the case. "Beasts Before Us" is the title of a book by Elsa Panciroli, about the very early evolution of mammals, going back to the time before there were mammals. Recognising whether an animal is a mammal today is easy enough – if it's got hair and, above all, if females make milk for their young in mammary glands then it's a mammal. Working out whether a fossilised skull can be classified a mammal may not be so easy. The lower jaw on each side being made of a single bone (the dentary) is one criterion. Also mammals have different sorts of teeth – incisors, canines, premolars and molars. A reptile lower jaw is made up of more than one bone on each side. In the evolutionary lineage which gave rise to mammals some of the bones of the lower jaw became smaller and became the bones of the inner ear – the hammer, anvil and stirrup, as you should remember from school biology lessons.

As it says in the book: "*What we didn't know until recently was how those jaw bones could have made the leap to their new home within the skull. Recent research …. suggests it was being small that allowed mammal jaws to transform. By analysing of nonmammalian cynodonts and early mammals, a team led by Stephan Lautenschlager discovered that having a smaller jaw (due to being smaller overall) meant the first mammals could bite harder while reducing the stresses placed on their jaw joints. This would have changed the way they bit, which had repercussions for the position of jaw muscles, freeing up the bones at the back of the jaw. These were then available for use in refined hearing.*" So to get superior ears you have to be small.

Later in the book we get further details: "*Mammal ears are a Mesozoic invention not just on the inside, but also on the outside. It is likely that until they had the middle and inner ear architecture to detect high frequency sound, the mammal lineage (and their predecessors) didn't have ear flaps on the outside of their heads either. This is because the pinnae are uniquely useful for determining the direction of higher frequency sound. In other tetrapods sound travels through the head between the ears. This helps an animal figure out which direction it came from because the brain interprets the pressure difference in the vibrations. In amphibians and reptiles, sound travels to the opposite ear via the bones around the mouth, whereas birds have an interaural canal. But mammals are unique because each ear is virtually isolated from the other, in the sealed recording studio of the petrosal bone. This poses a problem for localising where a noise originated. Once again miniaturisation may have had a key role to play in solving the problem. In the 1960s researchers noticed that smaller mammals tended to hear higher frequencies. Upon closer examination, they realised it wasn't the overall body size that was important, but the distance between the ears. The smaller an animal, the less time it took for sound to be detected by each ear. Mammals not only use this time difference to work out sound direction, but they also use the intensity of the sound at each ear. It turned out that when the distance between the ears was extremely small, higher frequencies were necessary for the intensity of sound to give meaningful information on direction*."

So it seems that for animals with the incredibly efficient echolocation of bats, that to us seems little short of miraculous, being small is part of the package.

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