Abstract

Acoustic communication is a key trait of anuran amphibians, as most species use it to locate and select conspecific mates for reproduction. In many species this behaviour is made possible by the tympanic middle ear that transfers sound vibrations, such as a mating call, from the surrounding environment to the inner ear, in which sound is processed. The sound conducting system has been of interest for many years, and researchers have investigated different aspects of it, from phonotactic behaviours to single unit responses of the auditory nerve. To this date no one has done a comparative study, that considers both the natural history of a species and the functional and physical properties of the middle ear. This study set out to uncover the relationship between the morphology of the middle ear and its biophysical properties as well as the neurophysiological sensitivity of the inner ear, in one species, the natterjack toad (*Epidalea calamita*). This species was selected, because it belongs to the family of true toads (Bufonidae), that have a complex evolutionary history concerning the tympanic middle ear. Since the last common ancestor (which was earless), there have been independent regains and losses of these structures. The implications of these fluctuations and the drivers behind are slowly being uncovered as interest in this phenomenon is growing. The natural history of the natterjack toad is also very well-studied, and authors like Ulrich Sinsch and Trevor Beebee have collected a large body of invaluable data about the species.

In this doctoral thesis I investigated the functional properties of the middle ear of the natterjack toad and compared that to literature on its natural history. I found that the middle ear of this species develops exceptionally slowly, and that age, contrary to intuition, is not the predicting factor of the timing of development, but that body size predicts the developmental stage and significantly influences when the middle ear becomes functional. Other studies have shown prolonged development of the middle ear in bufonid species, but this study provides the first definitive timeline spanning from newly metamorphosed toadlets to mature reproductive adults.

In collaboration with colleagues, I explored different approaches of the ABR (auditory brainstem response) method, a method for measuring auditory sensitivity. We found that using masked transients as stimulation was effective and neat, since it both monitors the anaesthetic state of the animal and derives relatively low thresholds. Methods that rely on phase-locking had similar low-frequency thresholds but deviated and produced higher thresholds at higher frequencies.

We also present a model that predicts the low-frequency sound induced vibrations of an animal, a model that correlates nicely with actual data. We propose that non-tympanic hearing in early tetrapods and extant earless amphibians function in accordance with this model.