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New progress on acoustic communication in the concave-eared torrent frog and its revelation

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Animals have special solution to the problem of communication in high levels of background noise. A small group of vertebrates (bats, dolphins and whales, and some rodents) that use ultrasound for communication. Our research first demonstrated that the concave-eared torrent frog is the first non-mammalian vertebrate found to be capable of producing and detecting ultrasounds for communication. This study may provide a clue for understanding why humans have ear canals and how animals auditory systems have evolved, and inspire in developing bionic tecnology for improving hearing in noise.

Key words concave-eared torrent frog, acoustic communication, ultrasonic hearing, background noise

Animal acoustic communication is one of the important evolutionary aspects. Many species of call-producing and well hearing animals usually use calls to attract mates for reproduction, detect and localize sounds to escape from predators for survival in complex habitats. How do the receivers recognise acoustic signals is not well known, in particularly, where signals are masked by the intense background noise for a number of frog species living nearby the noisy torrents and waterfalls.

The concave-eared torrent frog (*Amolops tormotus*, previously known as *Rana tormotus*) is restricted in its distribution to Mt. Huangshan and along Fuchun River of China. It inhabits vegetation alongside streams in mountains and hills at elevations around 150 to 700 m. Recent results have shown that the males produce countless vocalizations, some of which share features of birdsong, e.g., ultrasonic (frequency greater than 20 kHz, inaudible for human) frequency components, multiple upward and downward FM sweeps, and sudden onset and offset of selective harmonic components within a call note[1,2]. Thus, the main energy of calls is far above that of predominantely low-frequency ambient noise from local streams. It can be considered as one of the evolutionary landmarks in this species for adapting to the circumstance. What is the behavioral meaning of those high-frequency calls?

Using acoustic behavioural, neurophysiological and anatomical techniques, we recently reported evidence of ultrasonic communication in the frog (*Amolops tormotus*) in *Nature* and other publications[3—5].

Regarding to the significances of this finding, it's the first time a non-mammalian animal, *Amolops tormotus*, has been found capable of communicating in the ultrasonic range. Beforetime only cetaceans, microchiropteran bats, and some rodents are known to produce and detect ultrasounds. Because ranids are a distinct evolutionary lineage from those mammals, it is of importance to understand how the frogs have evolved ultrasonic communication systems.

Next, *Amolops tormotus* is termed since its eardrums are deeply sunken in the skull, whereas most other frogs have the eardrums on the body surface without ear canal. What is the function of the recessed ear canals? The evidence showed that ultrasounds mediated only by acoustic stimulation of the ear can be perceived by the frog. Similar to the bats' tympanic membranes, the frog's eardrums are extremely thin, 3—4 μm at the rim and 17—18 μm towards the centre, facilitating transmission of ultrasounds to the inner ear. It is open whether ear canal may be the peripheral mechanism of ultrasonic sensitivity. It is inspired from this study that ear canals can improve sensitivity to high-frequency sounds.

Thirdly, the ambient noise has a stong impact on acoustic communication[6]. How to cope with the interference of noise? *Amolops tormotus* shifts upward the frequency of acoustic signals above noise. The tactics meets the principle to economize the organism energy, other than increasing only sound intensity. The research may one day enable scientists to develop new strategies or technologies that help people to hear in noisy environments.

Finally, the extraordinary auditory mechanisms in *Amolops tormotus* may help to develop new treatments for hearing loss. For example, new ultrasonic devices will be designed to benefit deaf people. The finding also suggests there are other species that communicate each other in some ways.

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References

[1] Feng AS, Narins PM, Xu C-H. Vocal acrobatics in a Chinese frog, *Amolops tormotus*. *Naturwissenschaften*. 2002, 89, 352—356.

[2] Narins PM, Feng AS, Lin WY, et al. Old world frog and bird vocalizations contain prominent ultrasonic harmonics. *J. Acoust. Soc. Am*. 2004, 115, 910—913.

[3] Shen JX, Yu ZL, Qiu Q, Xu ZM. Male calls and ambient noise. *Acta Biophysica Sinica*, 2005, 21, Suppl, 73.

[4] Feng AS, Narins PM., Xu CH, et al. Ultrasonic communication in frogs. *Nature*, 2006, 440: 333—336.

[5] Shen JX, Yu ZL, Xu ZM, Feng A, Narins P. The concave-eared torrent frog uses ultrasound in communication. *Acta Biophysica Sinica*, 2006, 22, Suppl, 79.

[6] Katti M, Warren PS. Tits, noise and urban bioacoustics. *Trends in Ecology and Evolution*, 2004, 19(3), 109—110.