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Acoustic Communication: Sound Advice from Piranhas

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An elegant new study has correlated the generation of sound patterns in the red-bellied piranha (*Pygocentrus nattereri*) with three distinct behaviours.

The proverb that barking dogs never bite might be true for the mammalian species but clearly not for the red-bellied piranha *Pygocentrus nattereri*, which is justifiably dreaded for its flesh-shearing bites. This carnivorous fish inhabits the wild rivers of South America and might be best known for its unique, sharp rows of teeth and bloody-minded craving for meat, which perhaps explains why only few daring scientists venture to study piranhas and their behaviour. Although it is well known that piranhas emit a drumming-like sound if they are taken out of water and kept in hand or in a gill net [1–3], there has been no satisfying explanation for this peculiar phenomenon yet. A recent study [4] took a new approach to demonstrate acoustic communication and associated behaviour in red-bellied piranhas. They recorded three sound patterns, elucidated the mechanisms of sound production, and could directly correlate the sounds with distinct social behaviours.

Most people consider fish to be mute overall, but we should listen again more carefully. There are a surprisingly high number of sonic species among teleost fish that have evolved different modes to produce a wide variety of acoustic signals, including the ability to hear them. How does it sound when fish speak to each other? Acoustic recordings lead to the expressive description of their phonetic language as ‘hums’, ‘growls’, ‘grunts’, ‘boatwhistles’, ‘hoots’, ‘chirps’, and many more (summarized in [5,6]). Two basic mechanisms exist by which fish generate these sounds: by muscle contractions inducing a displacement of the
swimbladder and by stridulation of bony body parts, such as the teeth or fins. Fish generally perceive underwater sounds through their lateral line and inner ear organs, transducing high and low threshold signals respectively [7–9]. In an impressive display of convergent evolution, one superorder of fish, the Ostariophysi, have even evolved the Weberian apparatus, which consists of a set of bones (Weberian ossicles) that connect the swim bladder with the auditory system.

When do fish raise their voice? Just like in other animals, acoustic communication in teleosts is predominantly used for conspecific communication. Soniferous fish vocalize in a seductive manner during courtship and mating, aggressively to defend their territory or to optimize spacing within fish schools, and they might produce alerting signals in danger. Arguably in contrast to humans, males are often more vocal than females. A well studied example is the male plainfin midshipman fish (*Porichthys notatus*), which “sings” to attract silent females to his nest for reproduction [10,11]. Although acoustic communication seems to play an important role in the social behaviour of teleosts, in most species surprisingly little is known about the context of vocalization and behaviour. The new study of Millot et al. [4] is an important contribution to closing this gap in our knowledge.

Millot et al. [4] explored not only the sounds of piranhas, but also the behavioural context in which they are used, and how they are generated. In order to correlate acoustic signals with behaviour, they simultaneously recorded audio- and video signals from a group of ten fish in a tank. Thereby, they could identify three different sounds, each associated with a distinct behaviour (Figure 1). The first sound had a fundamental frequency of approximately 120 Hz and resembles the barking of a dog. In most cases fish generated this call during head-on confrontations with a conspecific potentially followed by direct contact but rarely biting.

A second signal was at an even lower fundamental frequency of approximately 40 Hz and sounds to human ears like drumming. It was most often observed when the piranhas
competed for food thereby circling around each other and fighting, bites inclusive. Usually the largest fish of the group generates this sound.

The last call analyzed had a relative high fundamental frequency of about 1740 Hz. Fish used it when they were chasing other fish with the intent of biting. In this case, the sound is produced by snapping of its jaw. This is in line with descriptions of other teleosts using stridulation of bony elements for acoustic communication [5]. In contrast, the first two types of sound were generated by movement of the swimbladder. It has been previously reported that, similar to other teleost fish [12], piranhas use fast-contracting sonic muscles to displace the walls of the gas-filled swimbladder in order to produce sound [2,3,13].

Millot et al. [4] further investigated the vibrations of the swimbladder with a sophisticated, new approach that included a laser Doppler vibrometer and stimulation of sonic muscles by electrodes. Thereby, they could show that only the cranial sac of the swimbladder is important for sound production. The caudal sac of the swimbladder is apparently not involved. Additionally, they found a direct correlation of the swimbladder vibration frequency with the sonic muscle contraction rate, meaning that the sound ceased as soon as muscle stimulation stopped.

Taken together, this exciting study by Mallot et al. [4] combined different new methods to analyze acoustic communication of piranhas at multiple levels. Importantly, they were able to correlate sound patterns with specific behaviour. Notably, these observed behaviour in the laboratory were only of aggressive nature feeding stereotypic view of the voracious piranha. Studies in the wild will have to follow to elucidate if there is a larger repertoire of sounds produced by gentle piranhas during mating behaviour. Hence, we are eagerly waiting for an update on the romantic vein of this teleost fish, not observable in captivity. Meanwhile, we should keep in mind we are smart to act on the sound advice of barking piranhas not to pick them up. All three dauntless scientists of this study ended up in hospital to get stitched after a piranha bite.
References


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Figure 1 Correlation of recorded sound patterns with observed behaviours in red-bellied piranhas (*Pygocentrus nattereri*).

The three different sound types produced by *Pygocentrus nattereri* and the behaviour that was associated with each sound in a test tank. Oscillograms and sonograms show the acoustic properties of the sound recorded in the lower panel (reproduced from [4] with permission from *The Journal of Experimental Biology*: jeb.biologists.org). The upper panel illustrates the correlated behaviour and a depiction of the sound’s nature in the speech bubble. (A) Piranhas emit a barking sound during conspecific confrontations. (B) A larger fish produces a drum-like sound during circling and fighting. This usually happens when piranhas compete for food. (C) Chasing and biting behaviour was associated with a rattling sound. (Piranha image credit: istockphoto.com)