Interspecific variation of warning calls in piranhas: comparative analysis

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Introduction

Fish sounds are often considered as species-specific with unique temporal and spectral features. Differences between acoustic signals of closely related species could be considered as pre-zygotic barrier and could be related to the evolutionary history of the species.

Objective

Sounds were recorded and compared in eight piranha species in order to evaluate the potential role of acoustic communication as a driving force in the diversification of piranhas.

Material & methods

- Recording of sounds by means of a hydrophone connected to a stereo recorder Tascam DR-07, when the fishes were hand-held
- Sound analysis with Avisoft-SASLab Pro
- Dissection and observation with a binocular microscope

Results & Discussion

1) Interspecific variation of acoustic signals

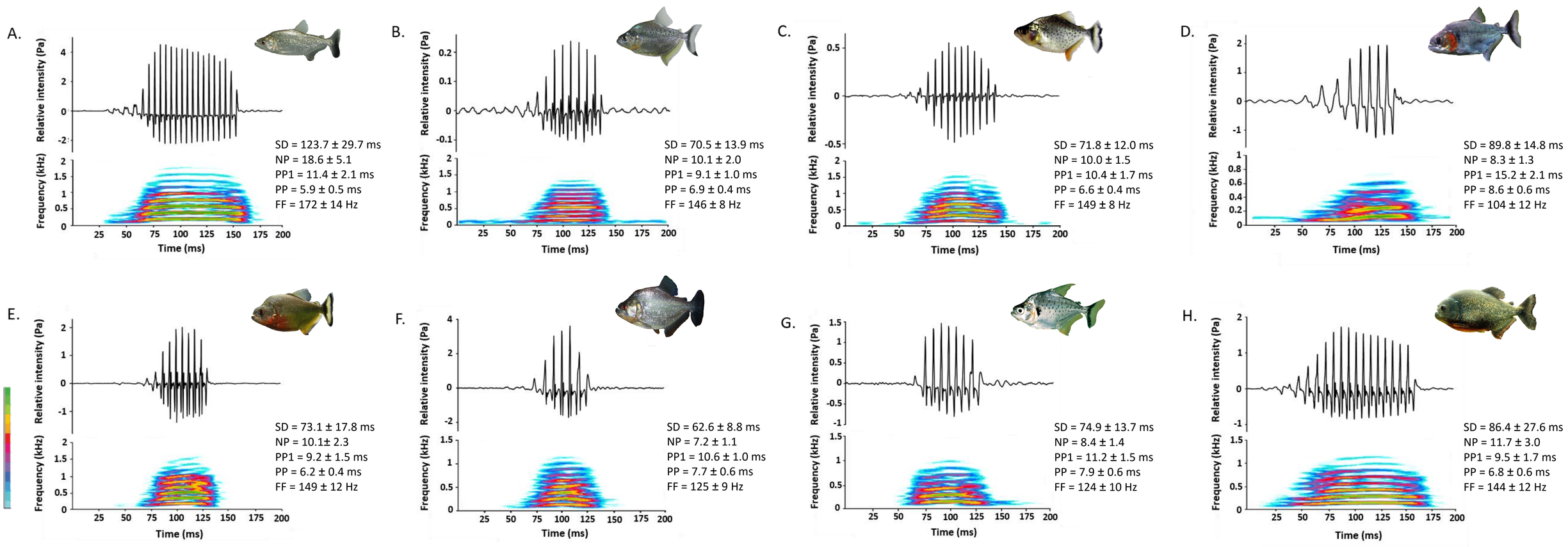

Figure 1. Waveform (above), spectrogram (below) and acoustic characteristics of the sounds produced by (A) *Serrasalmus elongatus* (n = 9); (B) *Serrasalmus marginatus* (n = 6); (C) *Serrasalmus compressus* (n = 7); (D) *Serrasalmus manueli* (n = 4); (E) *Serrasalmus spilopleura* (n = 7); (F) *Serrasalmus rhombeus* (n = 8); (G) *Serrasalmus eigenmanni* (n = 10); (H) *Pygocentrus nattereri* (n = 12).
SD, Sound Duration; NP, Number of Pulses; PP1, First Pulse Period; PP, Pulse Period; FF, Fundamental Frequency; n, number of recorded individuals per species

	PC1	PC2
Sound duration	-0.453	**0.869**
First pulse period	0.532	**0.823**
Fundamental frequency	**-0.979**	0.045

- *Serrasalmus elongatus*
- *Serrasalmus marginatus*
- *Serrasalmus compressus*
- *Serrasalmus manueli*
- *Serrasalmus spilopleura*
- *Serrasalmus rhombeus*
- *Serrasalmus eigenmanni*
- *Pygocentrus nattereri*

Figure 2. Scatterplot of principal component (PC) 1 versus PC2, performed with individual mean values of the three acoustic properties. PCA loadings for the two axes extracted from the three acoustic properties are presented in the table at the top right.

2) Sound-producing mechanisms

Figure 3. Schematic left lateral view of the sound-producing apparatus in (A) *Pygocentrus nattereri* and (B) *Serrasalmus compressus*. Note that the same sonic mechanism as in (A) is found in *S. eigenmanni*, whereas *S. elongatus*, *S. marginatus* and *S. rhombeus* possess the same mechanism as in (B).

The same kind of sound-producing mechanism was found in all the species: sonic muscles originate on vertebrae and attach to a tendon surrounding ventrally the bladder (Fig.3). Contractions of the sound-producing muscles force swimbladder vibration. Having the same kind of sound-producing mechanism, the calling features of the eight piranha species show logically many common characteristics. In all the species, the calls are harmonic sounds composed of several pulses without inter-pulse interval (Fig.1). It was possible to discern species-specific sounds, but the differences among species could be, in part, explained by the size. Only the sounds of *Serrasalmus elongatus* and *S. manueli* are really distinguishable from the other species (Fig.2). *Serrasalmus elongatus* differed by having a higher number of pulses and high-pitched fundamental frequency, whereas *S. manueli* differed by having long pulse periods and a low fundamental frequency.

Conclusion:

In the framework of this study, acoustic communication cannot be considered as the main driving force in the diversification process of piranhas. However, this channel could play an important role in some species. Modifications of the calls seem related to modifications at the level of the neural system.

Poster presented in Vienna for the 8th European Conference on Behavioural Biology - July 2016