



Sound production in three sympatric catfish species in the Merín Lagoon, Uruguay-Brazil

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Abstract: This study investigates sound production in three sympatric catfish species from the Merín Lagoon (Uruguay-Brazil): *Parapimelodus nigribarbis*, *Pimelodella australis*, and *Pimelodus pintado*. We recorded and characterized the sounds emitted by these species, focusing on the functional morphology of their sound-producing mechanisms and evaluating acoustic differences among them. All three species produce sounds via pectoral spine stridulation and swimbladder muscle contractions, using extrinsic sonic muscles. These sounds are typically emitted in distress situations. Our results show significant differences in stridulation sounds among the three species, while muscle sounds were similar. This suggests that stridulatory and swimbladder sounds serve as distress signals, potentially playing roles in intraspecific communication and predator deterrence. This research enhances our understanding of the bioacoustics and communication strategies of Neotropical catfish. Moreover, it highlights the ecological importance of sound production in these species, contributing to knowledge useful for their conservation in the Merín Lagoon ecosystem.

Keywords: Underwater bioacoustics, stridulation sound, muscle sound, distress sound, disturbance.

Produção de sons em três espécies simpátricas de bagres na Lagoa Mirim, Uruguai-Brasil.

Resumo. Este estudo examina a produção sonora em três espécies simpátricas de bagres da Lagoa Mirim (Uruguai-Brasil): *Parapimelodus nigribarbis* (Pimelodidae), *Pimelodella australis* (Heptapteridae) e *Pimelodus pintado* (Pimelodidae). Os sons emitidos por essas espécies foram registrados e caracterizados, descrevendo-se a morfologia funcional de seus mecanismos de produção sonora e avaliando-se as diferenças acústicas entre elas. As três espécies produzem sons por estridulação do espinho peitoral e sons com a bexiga natatória por meio de músculos sônicos extrínsecos. Ambos os tipos de som são emitidos em situações de estresse. Diferenças significativas foram encontradas nos sons de estridulação entre as três espécies, mas não nos sons musculares. Esses achados sugerem que os sons de estridulação e os sons da bexiga natatória funcionam como sinais de alarme, com possíveis implicações para a comunicação intraespecífica e para a dissuasão de predadores. Este estudo contribui para a compreensão da bioacústica de bagres neotropicais e suas estratégias de comunicação e defesa, bem como para o papel do som na ecologia e conservação dessas espécies na Lagoa Mirim.

Palavras-chave: Bioacústica subaquática, Som de estridulação, Som muscular, Som de angustia, Perturbação.

Introduction

Sound plays an important role in fish species identification (Winn, 1964; Fine *et al.*, 1977; Mok & Gilmore, 1983; Ladich & Fine, 2006; Amorim, 2008; Parmentier *et al.*, 2009; Phillips & Johnston, 2008; Tellechea *et al.*, 2010, Borie *et al.*, 2014; Tellechea *et al.*, 2022). Passive acoustics has been used to record temporal and spatial patterns of fish reproduction by detecting sounds associated with spawning (Lobel & Mann, 1995; Lobel, 2001; Anderson *et al.*, 2008; Luczkovich *et al.*, 2008; Tellechea *et al.*, 2010a; 2010b) and with disturbance or agonistic behavior (Tellechea *et al.*, 2010a, 2010b; 2011).

Catfishes are well known to produce sounds during courtship, agonistic behavior (Ladich & Fine, 1994; Kaatz, 1999; Tellechea *et al.*, 2011), and in response to disturbance (Fine *et al.*, 1997; Heyd & Pfeiffer, 2000; Fine & Ladich, 2003). The first contexts in which sound production was registered were various distress situations, *e.g.* when fish were handled or caught (Ladich, 1997b). Systematic studies on sound producing abilities of fish subjecting animals to a variety of stressful stimuli demonstrated that acoustic signals are widespread in teleosts (Fish *et al.*, 1952; Fish & Mowbray, 1970, Tellechea *et al.*, 2011; Tellechea 2019).

Siluriformes (the catfishes) is a very species-rich order, with approximately 2,700 species (Teugels, 2003). Some species of catfish produce sounds through pectoral-fin spine stridulation or through swim bladder contraction driven by sonic muscles, and some are able to produce sounds through both mechanisms (Kaatz & Stewart, 1997; Kaatz, 1999; Kaatz & Lobel, 1999; Kaatz & Lobel, 2001; Ladich & Fine, 2006; Kaatz *et al.*, 2010; Tellechea *et al.*, 2011; Kaatz & Stewart, 2012), with different mechanisms being used under different behavioral contexts (Kaatz, 2002).

Drumming sounds result from the contraction of sonic muscles in relation to the swimbladder (Ladich, 1997b; Parentier *et al.*, 2006). In the second mechanism, the majority of catfish families use their pectoral spines, and one family, the sisorids, uses their dorsal spine only (Mahajan, 1963), to produce stridulatory sounds (Gainer, 1967; Schachner & Schaller, 1981; Kaatz, 1999; Kaatz & Lobel, 1999; Kaatz & Lobel, 2001; Fine & Ladich, 2006; Kasmayan, 2008; Friel & Vigliotta, 2006).

Several catfish families possess two sonic mechanisms (Sorensen, 1895). One is sound produced by stridulation, generated by small bony ridges located on the proximal end of the pectoral fin spine that are rubbed against a rough surface on the cleithrum (Fine *et al.*, 1997). The other mechanism involves swimbladder drumming muscles, which are absent in several catfish families (Siluridae, Ictaluridae, Loricariidae, Callichthyidae). In contrast to pectoral spine stridulation, swimbladder sonic mechanisms are highly diverse and often characteristic of each family (Ladich, 1997b). Stridulatory sounds in catfish have been observed during agonistic encounters in undisturbed aquarium populations (Kaatz, 1999). The pectoral spines of catfish are thought to deter predation through warning behavior and by increasing the effective size of the fish (Endler, 1986; Fine & Ladich, 2003). Boshier *et al.* (2006) documented that catfish pectoral spines can harm or kill predators; however, experimental evidence directly linking pectoral spines to predation deterrence remains limited. Sismour *et al.* (2013), in an experimental study using net pens, showed that largemouth bass consumed significantly fewer juvenile channel catfish than alternative prey, suggesting a potential deterrent effect of pectoral spines. Recher and Recher (1968) showed an increased escape rate of prey from avian predators associated with the presence of spines, although they did not describe their use as an active defense mechanism.

Three species of siluriformes inhabit the Merín Lagoon (Uruguay-Brazil) (see map figure 1); *Parapimelodus nigribarbis*, *Pimelodus pintado* family Pimelodidae and *Pimelodella australis* family Hep-tapteridae. These species are very abundant and inhabit coastal areas of the lagoon. This study aims to record and acoustically characterize the sounds produced by *Parapimelodus nigribarbis*, *Pimelodus pintado* and *Pimelodella australis*, to describe the functional morphology of their sound production mechanisms. Additionally, the study seeks to determine whether significant acoustic differences exist both between sexes within each species and among the three species. We hypothesize that sex-based differences in sound characteristics may be present within each species, and that interspecific variation in acoustic signals may also occur, potentially reflecting species-specific communication or morphological traits.

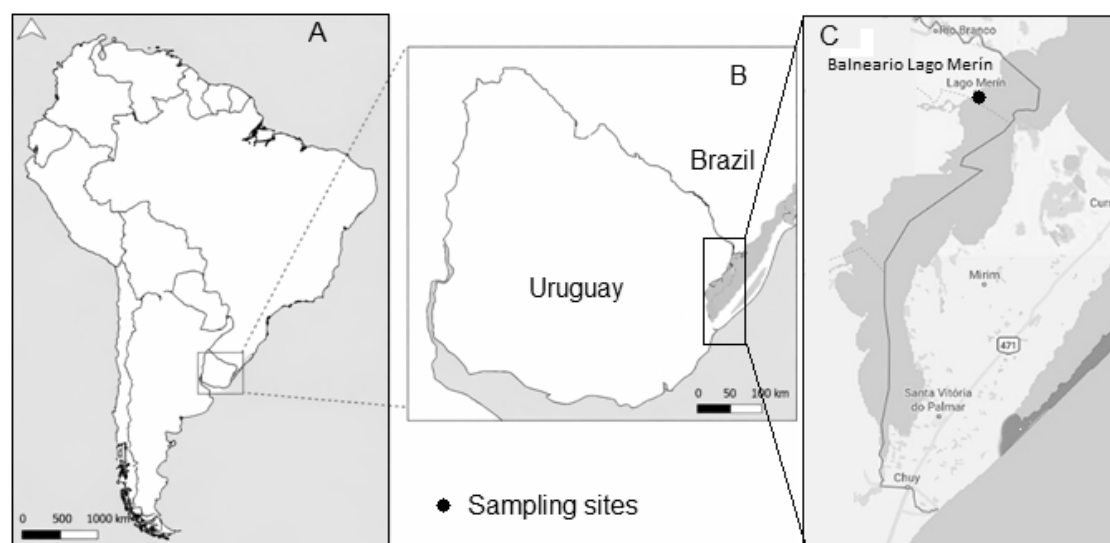


Figure 1. Map of the Laguna Merín showing the sampling areas where specimens were collected by artisanal fishermen along the Uruguayan coast.

Material and methods

Fish were collected by an artisanal fisherman in the Laguna Merín on the Uruguayan coast, near the summer village "Balneario Lago Merín" (32° 44' 30" S, 53° 15' 35" W) (Figure 1), using multi-mesh gillnets set in various coastal areas of the lagoon. Two field trips were conducted to collect specimens, one in winter (in situ water temperature: 15 °C) and another in spring (in situ water temperature: 20 °C) of the southern hemisphere in 2021.

Immediately after collection, the specimens were removed from the nets and placed in a single 300-L tank (100 × 50 × 60 cm; water depth: ~50 cm) containing lagoon water at 15–17 °C. Fish were then separated by species into two additional 300-L tanks of the same dimensions for temporary housing. Each group was allowed to acclimate in these tanks for approximately 2 hours before recordings began. No feeding was provided during this period, as recordings were conducted immediately following capture and transportation.

Acoustic recordings were carried out individually. Each fish was captured with a hand net and transferred to a 70-liter recording tank. During recordings, the fish was first positioned with a small hand net and then gently restrained by holding the dorsal fin with a gloved hand to prevent movement and ensure consistent positioning at a standardized distance of 1 m from the hydrophone. The use of gloves was necessary to avoid injury due to the sharp and potentially harmful pectoral spines. This procedure ensured consistent acoustic conditions and minimized variability due to amplitude or position. Each fish remained in the tank only for the time re-

quired to complete the recording (approximately 2–5 minutes).

Once the recording was completed, the specimen was euthanized with an overdose of 2-Phenoxy-Ethanol (1 ml l⁻¹). This procedure was followed consistently during both field trips. Biological measurements, including total length (cm), body weight (g), and sex, were then obtained. Additionally, a male and female of each species were dissected to describe and analyze sound production structures.

Recordings were made with a hydrophone built in the laboratory (sensitivity: -40 dB re 1 µPa; linear from 20 Hz to 60 kHz) connected to a TASCAM HD-P2 digital recorder, with a sampling frequency of 44.1 kHz. Simultaneously, a Nikon D7500 video camera recorded sound production and fish movements to determine whether sounds were produced during abduction or adduction of the pectoral spine.

Sound analyses were performed with Audacity (v.1.2.3) and Raven Pro 1.6 (K. Lisa Yang Center for Conservation Bioacoustics, 2019). Power spectra were calculated using a 1024-point FFT with a Hanning window. The following parameters were measured: number of trains, pulse duration, pulse interval, and dominant frequency.

Statistical analyses were conducted with PAST (v.1.95; Hammer et al. 2001). Male and female sound characteristics were compared using Student's unpaired t-test (Sokal & Rohlf, 1995). Differences among species were assessed with one-way ANOVA followed by Tukey's post hoc test. The Levene test was used to test homogeneity of variances (Levene, 1960). A critical α -level of 0.05 was

adopted. Given the unequal number of sound trains per species and per individual, mean values of each acoustic parameter were calculated per individual and used in analyses.

For *Pimelodella australis*, only two individuals (one male and one female) were recorded. Owing to this limited sample size, the results are presented solely descriptively, without comparative statistical analysis. In contrast, larger samples of *Parapimelodus nigribarbis* and *Pimelodus pintado* allowed statistical comparisons both between sexes and between species.

The studied specimens were not preserved. Voucher material for all three species is available in the ichthyological collection of the Facultad de Ciencias, Universidad de la República, Montevideo, Uruguay: ZVCP15582 (*Parapimelodus nigribarbis*), ZVCP15584 (*Pimelodus pintado*), and ZVCP15585 (*Pimelodella australis*).

Results

Sound production mechanisms. The three species *Parapimelodus nigribarbis* (n = 26; total length 11.5–14.2 cm; 9 males and 17 females) and *Pimelodus pintado* (n = 5; total length 10–24.6 cm; 2 males and 3 females), as well as *Pimelodella australis* (n = 2; total length 8.2–9.5 cm; 1 male and 1 female), all belonging to the family Pimelodidae, emitted two different types of sounds: (1) a drumming or sonic muscle sound, produced by the contraction of the sonic muscle attached to the swimbladder, and (2) a stridulatory sound, produced by the movement of the pectoral spines. Both sound types were emitted by males and females.

All acoustic recordings (both sonic muscle and stridulatory sounds) were conducted underwater. Although some individuals also emitted sounds in air when handled (e.g., during transfer between tanks or when entangled in nets), only underwater emissions were recorded and analyzed in this study. In all cases, sound production occurred in response to physical restraint: when the fish was held stationary with a hand net and unable to move freely, it produced these agonistic sounds, which we interpret as part of a stress or defense response.

Drumming sounds were low-frequency harmonic signals composed of single pulses (see oscillograms in Fig. 2). These were sometimes produced simultaneously with, or immediately after, stridulatory sounds, though in some cases they occurred independently. Stridulatory sounds generally exhibited higher dominant frequencies than muscle sounds (e.g., in *Parapimelodus nigribarbis*, 1914 ± 786 Hz

vs 1076 ± 186 Hz). In addition, *Pimelodella australis* showed notably longer pulse durations and intervals during stridulation (26.1 ± 15.1 ms and 69.4 ± 19.4 ms, respectively), compared to muscle sounds. Mean acoustic variables of drumming sounds are shown in Table 1.

Stridulatory sounds were produced during the abduction of one pectoral spine. As observed in other catfish species, the fish emitted a pulse each time the pectoral spine was abducted, producing a train of pulses by alternately abducting the pectoral fins, both underwater and in air. However, as stated before, only underwater emissions were recorded. The fish could also move the fins silently or maintain the spines in a locked abducted position. Dissections revealed that the base of the spine has a dorsal process with a series of ridges on its ventrolateral surface; the sound results from friction between these ridges and the dorsal process during spine movement. Stridulatory sounds consisted of a train of pulses and were produced when the fish was held by the dorsal fin or otherwise immobilized (Fig. 2). Descriptive statistics for these sounds are shown in Table 1. Differences were observed both among species and between sound types. In *Parapimelodus nigribarbis*, muscle sounds showed short pulse durations (mean = 2.47 ms) and lower dominant frequencies (≈ 1076 Hz), whereas stridulation sounds exhibited slightly shorter pulses but higher dominant frequencies (≈ 1914 Hz). In *Pimelodella australis*, both pulse duration and interval were notably longer than in the other species, particularly in stridulation sounds (mean pulse duration ≈ 26.1 ms; interval ≈ 69.4 ms). In contrast, *Pimelodus pintado* produced the shortest muscle pulse durations (mean = 1.45 ms) and relatively low dominant frequencies (901 Hz), while stridulation sounds showed higher frequencies (≈ 1516 Hz) and greater variability in temporal parameters. Across species, stridulation sounds consistently exhibited higher dominant frequencies than muscle sounds, while temporal parameters varied substantially among taxa.

In the 300-liter holding tanks, no stridulatory sounds were observed under normal conditions. However, all three species were observed to emit stridulatory sounds in situ when entangled in fishing nets. In contrast, drumming sounds were not heard or recorded during such events in the wild.

The mechanisms underlying sound production in these species are illustrated in Figure 3.

Acoustic parameters comparison. No differences between male and female muscle sounds were found for any of variables analyzed in *Parapimelodus ni-*

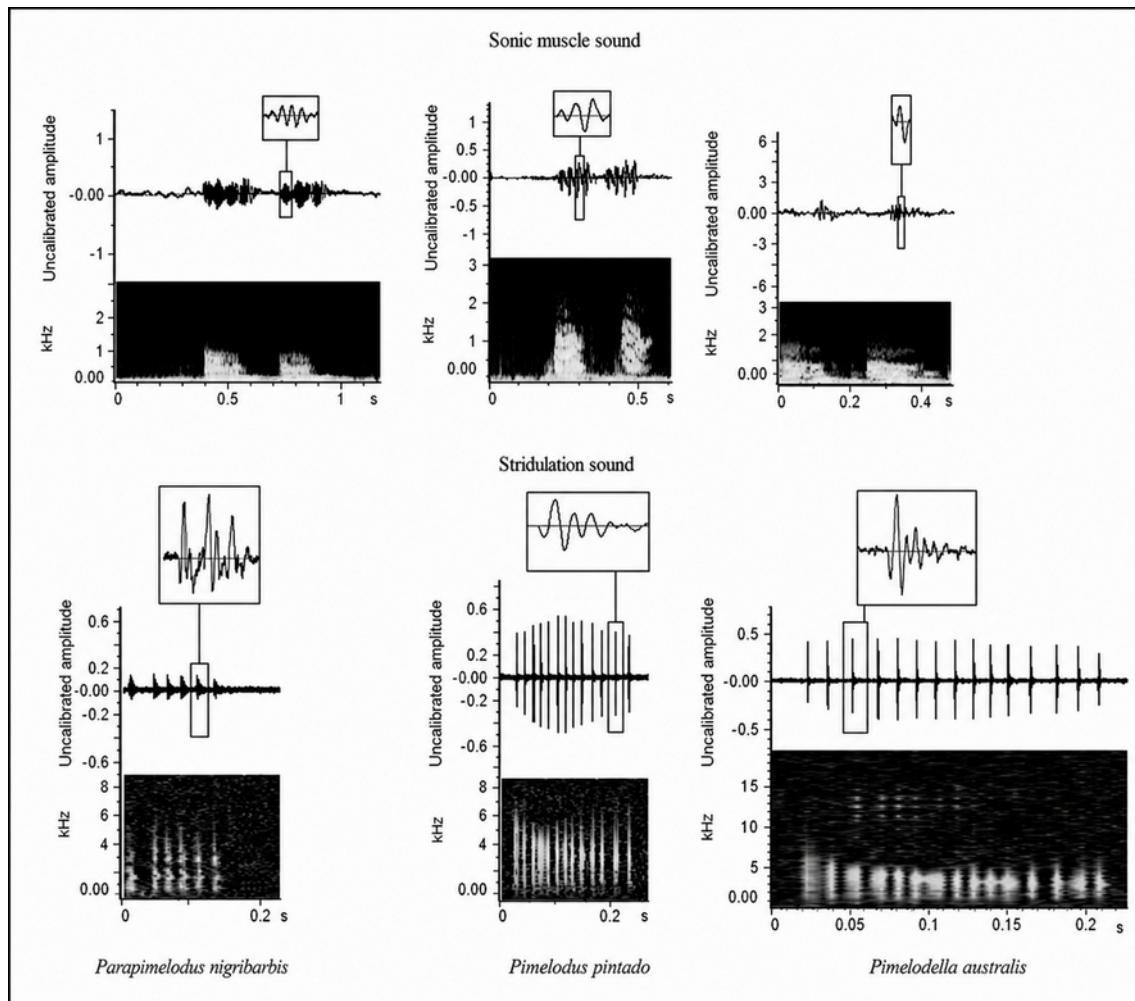


Figure 2. Sonic muscle sound and stridulation sound example of each species recorded in a 70 l canvas tank. For each sound Oscillogram above (uncalibrated relative amplitude on the y-axis) and below spectrograms (Hann window function and fast Fourier transformation size of 1024 points). At each oscillogram can see a zoom window with a simple pulse.

gribarbis and *Pimelodus pintado* (Fig. 4). In *Parapimelodus nigribarbis*, 31 muscle sound trains (12 from males and 19 from females) were analyzed, showing no significant differences in pulse duration ($p = 0.29$), pulse interval ($p = 0.71$), or dominant frequency ($p = 0.43$). For *Pimelodus pintado*, 44 muscle sound trains (18 from males and 26 from females) were analyzed, also with no significant differences between sexes in pulse duration ($p = 0.59$), pulse interval ($p = 0.21$), or dominant frequency ($p = 0.60$).

Similarly, no differences between male and female stridulation sounds were found for the same two species. In *Parapimelodus nigribarbis*, 127 stridulation sound trains (73 from males and 54 from females) were analyzed, with no significant differences in pulse duration ($p = 0.27$), pulse interval ($p = 0.72$), or dominant frequency ($p = 0.34$). For *Pimelodus pintado*, 9 stridulation sound trains (6

from males and 3 from females) were analyzed, also with no significant differences between sexes in pulse duration ($p = 0.12$), pulse interval ($p = 0.48$), or dominant frequency ($p = 0.83$).

For sonic muscle sound, no significant differences were found between *Parapimelodus nigribarbis* and *Pimelodus pintado* in pulse duration, interpulse interval, or dominant frequency. In the case of stridulation sounds, significant differences were detected between the two species in pulse duration ($F_{1,15} = 6.8$, $p < 0.01$) and interpulse interval ($F_{1,14} = 7.1$, $p < 0.01$), but not in dominant frequency ($F_{1,15} = 4.6$, $p = \text{n.s.}$).

Descriptive values of the acoustic parameters for *Pimelodella australis* are shown in Table 1, but no statistical comparisons were made due to the low number of individuals ($n = 2$).

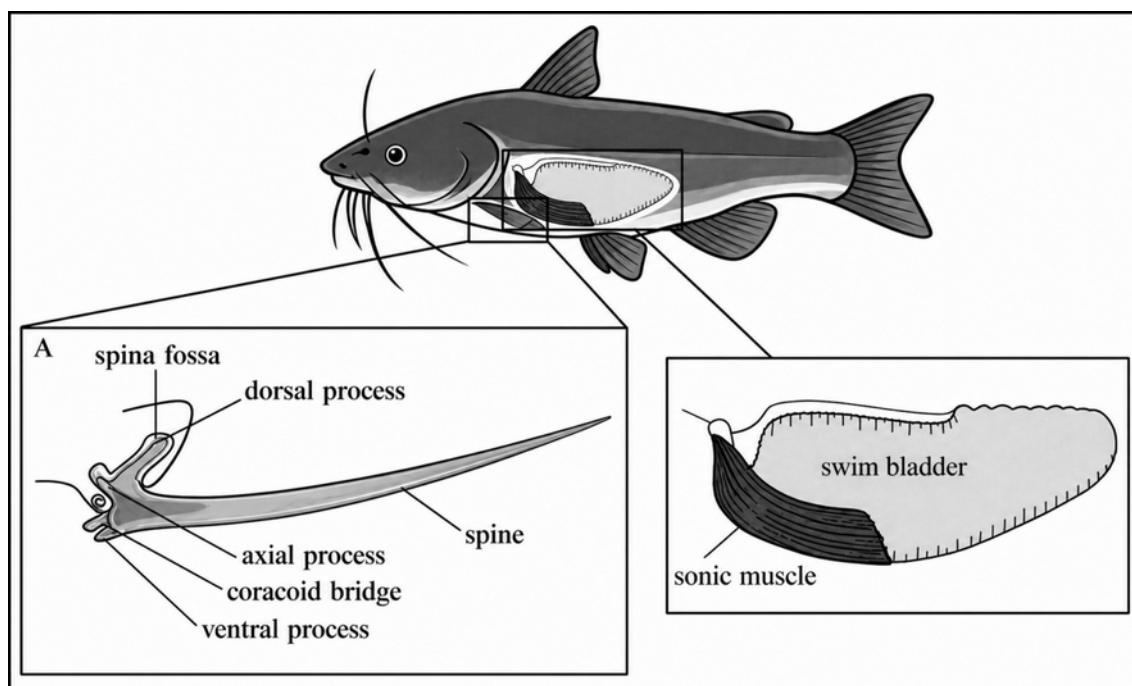


Figure 3. Schematic representation of sound production mechanisms in catfish. (A) Stridulation mechanism: sound is produced by the movement of the pectoral spine, where ridges located on the dorsal process scrape against the spina fossa of the pectoral girdle, generating a series of pulses through bone-on-bone friction. (B) Drumming mechanism: sound is generated by the contraction of sonic muscles attached to the swim bladder, producing its vibration and resulting in tonal acoustic signals. These mechanisms correspond to the sound production system of the three catfish species recorded in this study (*Parapimelodus nigribarbis*, *Pimelodus pintado*, and *Pimelodella australis*).

Table I. Acoustical parameters for drumming sound, ms = milliseconds, Hz = Hertz. Number of sounds analyzed in *Parapimelodus nigribarbis* : muscle sounds n = 8 and stridulation n = 21; in *Pimelodus pintado* muscle sounds n = 5 and stridulation n = 4, and in *Pimelodella australis* muscle sounds n = 3 and stridulation n = 2.

Muscle sound				Stridulation sound			
<i>Parapimelodus nigribarbis</i>	Mean ($\pm$ SD)	Min	Max	<i>Parapimelodus nigribarbis</i>	Mean ($\pm$ SD)	Min	Max
Pulse duration (ms)	2,47 $\pm$ 1,78	1	5,96	Pulse duration (ms)	2,18 $\pm$ 1,95	1	4,8
Pulse interval (ms)	1,45 $\pm$ 4,02	1,07	2,01	Pulse interval (ms)	2,80 $\pm$ 1,70	1,01	5,66
Dominant frequency (Hz)	1076 $\pm$ 186,2	325	1890	Dominant frequency (Hz)	1914 $\pm$ 786,3	776	3413
<i>Pimelodus pintado</i>				<i>Pimelodus pintado</i>			
Pulse duration (ms)	1,45 $\pm$ 0,41	1,07	2,1	Pulse duration (ms)	2,81 $\pm$ 1,71	1	5,66
Pulse interval (ms)	2,87 $\pm$ 3,79	1	70,6	Pulse interval (ms)	5,80 $\pm$ 8,39	0,02	20,5
Dominant frequency (Hz)	901 $\pm$ 112,2	743	1041	Dominant frequency (Hz)	1516 $\pm$ 472	874	1923
<i>Pimelodella australis</i>				<i>Pimelodella australis</i>			
Pulse duration (ms)	8,47 $\pm$ 9,82	1	22,5	Pulse duration (ms)	26,1 $\pm$ 15,1	3,47	35
Pulse interval (ms)	12,3 $\pm$ 6,19	5,28	20,4	Pulse interval (ms)	69,4 $\pm$ 19,4	55,3	98,2
Dominant frequency (Hz)	992 $\pm$ 103,7	896	1138	Dominant frequency (Hz)	1261,3 $\pm$ 166,5	111	1426

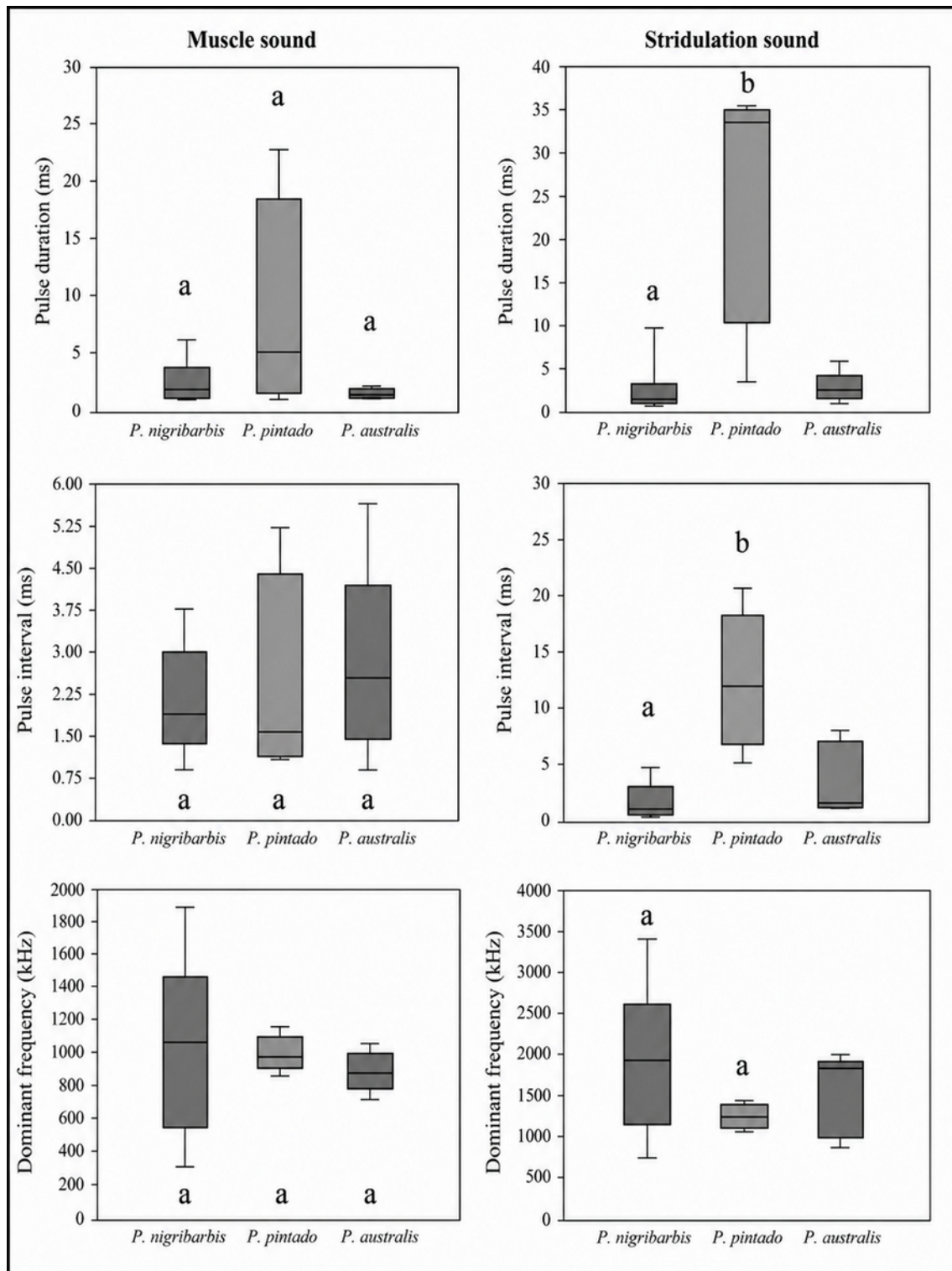


Figure 4. Boxplots of acoustic parameters (pulse duration, ms; pulse interval, ms; dominant frequency, Hz) for sonic muscle and stridulation sounds in the three species. Boxes represent the median and interquartile range, and whiskers indicate the range. Different letters indicate significant differences among species ($p < 0.05$). *Pimelodella australis* was not included in statistical comparisons due to low sample size ($n = 2$).

Discussion

This study documents sound production in three species from the Merín Lagoon, Uruguay:

Parapimelodus nigribarbis and *Pimelodus pintado* (Pimelodidae), and *Pimelodella australis* (Hep-
tapteridae). Both males and females of all species

produced pectoral stridulation and swimbladder drumming sounds when handled, either by being held by the dorsal fin with a hand net underwater or otherwise immobilized under distress conditions. Catfishes are unique among teleosts for possessing two distinct sound-producing mechanisms: the pectoral spines and the swimbladder. The morphology of these structures exhibits notable variation across families. In doradids, the pectoral spines are the largest, mochokids show intermediate sizes, and pimelodids have the smallest (Ladich et al., 1997b). Although the general morphology of the spine and

Our results show interspecific differences in stridulation. In *Parapimelodus nigribarbis* and *Pimelodus pintado*, sounds were only produced during abduction of the pectoral spine, similar to *Ictalurus punctatus* (Fine et al. 1996) and *Iheringichthys labrosus* (Tellechea et al. 2011). In contrast, *Pimelodella australis* produced sounds during both abduction and adduction, a pattern also found in some aspredinids and ictalurids (Gainer, 1967; Rigley & Muir, 1979). The presence of ridges on the dorsal process of the proximal spine end appears essential for sound production (Parmentier et al. 2010). As in other pimelodids, these stridulatory sounds were triggered by distress situations, such as handling or capture (Ladich & Fine, 2006).

Drumming sounds in the three species were produced by the extrinsic swimbladder muscle (Ladich & Fine, 1994), which originates from the transverse process of the fourth vertebra and inserts ventrally on the swimbladder (Schachner & Schaller, 1981). However, this muscle is not present in all pimelodids, and its absence is often associated with atrophy of the swimbladder (Bridge & Haddon, 1889; Ladich & Fine, 2006). The drumming sounds we recorded were harmonic, pulse-like signals, consistent with previous observations in *Pimelodus blochii*, *P. pictus* (Ladich, 1997b), and *I. labrosus* (Tellechea et al. 2011). In our experiments, drumming usually followed or accompanied stridulation, although it was occasionally produced alone, as also reported for *P. blochii*, *P. pictus* (Ladich, 1997b), and *I. labrosus* (Tellechea et al. 2011). Quantitatively, the acoustic parameters recorded in this study were generally consistent with those reported for other pimelodids. Stridulatory pulse durations (≈ 2 – 3 ms) were comparable to values reported by Ladich (1997b) for *Pimelodus blochii* and *P. pictus* (0.6–2.4 ms), and to those described for *Iheringichthys labrosus* (≈ 1.34 ms; Tellechea et al. 2011). Pulse intervals (≈ 2 – 6 ms) also fell within the range reported for pimelodids (≈ 3.5 – 9.9 ms), considering differences

associated muscles is relatively conserved (Fine et al., 1997; Diogo et al., 2001), several muscles such as the arrector dorsalis and arrector ventralis also participate in sound production (Fine et al. 1996; Kaatz, 1999; Heyd & Pfeiffer, 2000; Fine & Ladich, 2003). Rather than being generated by single ridges, stridulatory sounds result from a sequence of jerky spine movements involving multiple ridges and muscles (Parmentier et al. 2010; Mohajer et al. 2015). Detailed descriptions of the pectoral musculature involved in sound production have also been provided for ictalurid catfishes (Miano et al. 2013). between abduction and adduction phases. However, stridulatory sounds in the present study exhibited substantially higher dominant frequencies (≈ 1261 – 1914 Hz) than those reported for *I. labrosus* (≈ 656 Hz; Tellechea et al. 2011). Even more pronounced differences were observed in drumming sounds: while previous studies reported low fundamental frequencies in pimelodids (≈ 165 – 177 Hz; Ladich, 1997b) and in *I. labrosus* (≈ 220 Hz; Tellechea et al. 2011), the species analyzed here produced markedly higher values (≈ 900 – 1076 Hz). Overall, these results indicate consistency in temporal parameters of sound production among pimelodids, while highlighting strong interspecific variation in spectral characteristics. This pattern may reflect differences in swimbladder size and tension or muscle contraction dynamics, as well as potential effects of recording conditions, although further investigation is needed to confirm these mechanisms. However, methodological differences among studies may also contribute to these discrepancies.

Another defensive mechanism observed in all three species was pectoral spine locking, which always preceded sound production. As shown in other catfishes, spine locking and stridulation are mutually exclusive (Bosher et al. 2006). This mechanical locking, enabled by a modified joint between the spine and girdle, increases the catfish's apparent size and deters predation attempts (Fine et al. 1997; Fine & Ladich, 2003). Although spine locking may not prevent capture, it may hinder ingestion and, in some cases, even injure predators (Endler, 1986; Bosher et al. 2006). Stridulation sounds may reinforce this defense by functioning as distress calls that attract secondary predators and increase the chance of escape (Bradbury & Vehrencamp, 1998).

At the acoustic level, stridulation results from friction between ridges of the dorsal process of the spine and the surface of the spinal fossa, producing a train of pulses (Fine et al. 1997). The fused pectoral girdle acts as a resonator, enhancing the radiated

sound power compared with teleosts with less ossified girdles (Fine *et al.* 1997). Therefore, the acoustic differences observed among the three studied species may stem from subtle variations in ridge morphology and spine-girdle articulation.

In agreement with previous studies, our results suggest that stridulation and drumming in *Parapimelodus nigribarbis*, *Pimelodella australis*, and *Pimelodus pintado* primarily serve as distress signals, while drumming may also play a role in reproductive contexts such as courtship or spawning. The combined use of acoustic signals and mechanical defenses highlights the complexity of anti-predator strategies in pimelodid catfishes.

Previous studies on sound production in catfish have reported recordings obtained under a variety of conditions, including laboratory aquaria, holding tanks, and field environments. For instance, both stridulatory and drumming sounds have been described in species recorded in captivity as well as in situ. In general, the acoustic parameters observed in the present study fall within the range reported for other catfish species, particularly in terms of pulse duration and dominant frequency. Stridulatory sounds are typically characterized by higher frequencies and pulsed structures, whereas drumming sounds tend to be more tonal and associated with swimbladder vibrations. These similarities suggest that comparable acoustic signals may occur in natural environments where these species inhabit (Ladich, 1997a; Ladich, 1997b; Fine & Ladich, 2003).

Future studies should combine high-speed imaging with acoustic recordings to quantify pectoral spine movements during stridulation and relate them to sound production. Such approaches would help clarify the functional significance of interspecific differences in pulse characteristics and ridge morphology on the dorsal process of the pectoral spine.

This study contributes to the understanding of the bioacoustics of Neotropical catfishes, adding valuable information on their communication and defense strategies, and provides a baseline for future research on the ecological and conservation relevance of sound production in the Merín Lagoon.

Ethical statement

The scientific collection and handling of animals for this research were approved by the Honorary Commission for Animal Experimentation (CHEA) of Uruguay (Approval No. 1207, File No. 1207), in accordance with national guidelines and

ethical standards established by the Uruguayan Animal Experimentation Ethics Committee.

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