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INDIVIDUALITY IN THE MATING CALL OF THE MALE LUSITANIAN TOADFISH (*HALOBATRACHUS DIDACTYLUS*)

INDIVIDUALNOST PARITVENEGA KLICA SAMCEV LUZITANIJSKIH GLAVAČEV (*HALOBATRACHUS DIDACTYLUS*)

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ABSTRACT

Individuality in the mating call of the male Lusitanian Toadfish (*Halobatrachus didactylus*)

During the breeding season, male Lusitanian Toadfish emit a tonal advertisement call (the boatwhistle) from their nests to attract mates. Boatwhistles begin and end with a grunt-like phase (P_1 and P_3) and contain a longer tonal portion in between (P_2). In this study we examined individuality in the Lusitanian Toadfish boatwhistles. Recordings (5-10 min) of 13 males were made in shallow waters in the Tagus estuary, Portugal. Ten sounds were analysed per male. Boatwhistles from different individuals could easily be distinguished by the human ear, and visually by differences in their spectra and shape of the temporal envelope. Acoustic features showed very little intra-individual variation (i.e. coefficient of variations ? 0.1), including boatwhistle duration, relative duration, number of pulses and pulse period of both P_1 and P_2, and the relative amplitude of P_1 in relation to P_2 (amplitude modulation). All acoustic variables differed significantly among individuals (Kruskal-Wallis: $P<0.001$). Discriminant function analysis assigned 95% of calls to the correct individuals, with boatwhistle duration, P_2 relative duration and amplitude modulation being the most important variables in the model. Individuality of mating sounds is unusual among fish and could be potentially used in mate choice and in spacing out territorial males.

Key words: Acoustic communication, boatwhistles, territoriality, mate attraction, Batrachoididae.

IZVLEČEK

Individualnost paritvenega klica samcev luzitanijskih glavačev (*Halobatrachus didactylus*)

Med obdobjem parjenja oddajajo luzitanijski glavači tonalni vabilni klic ("ladijski žvižg") s svojih gnezd ,da privabijo spolne partnerje. Žvižgi se začnejo in končajo s kruljenju podobno fazo (P_1 in P_3), ki se v sredini spremeni v dolg tonalni del (P_2). V tej študiji sta avtorici proučevali individualnost teh klicev. Posnetki (5-10 min) 13 samcev so nastali v plitvinah izliva reke Tagus na Portugalskem. Analizirali sta po 10 klicev vsakega osebka. "Ladijske" žvižge različnih samcev ni težko razlikovati s prostim ušesom in tudi vizualno po razlikah v spektru in po obliki časovne ovojnice signala. Akustični parametri, ki vključujejo absolutno in relativno trajanje žvižga, število in periodo pulzov med kruljenjem (P_1 and P_3) in relativno amplitudo segmentov P_1 in P_2 (amplitudna modulacija), kažejo zelo majhne razlike med klici posameznih osebkov (koeficient variabilnosti ? 0,1). Vse akustične spremenljivke se značilno razlikujejo med posameznimi osebki (Kruskal-Wallis: $P<0{,}001$). Analiza funkcije diskriminant je določila 95 % klicev pravim osebkom, kot najpomembnejše spremenljivke so se pri modelu pokazali trajanje signalov, relativno trajanje faze P_2 in amplitudna modulacija. Individualne razlike med paritvenimi klici so neobičajne za ribe in so verjetno pomembne pri izbiri spolnih partnerjev in pri prostorski razporeditvi teritorialnih partnerjev.

Ključne besede: zvočna komunikacija, "ladijski žvižgi", teritorialnost, privabljanje spolnih partnerjev, Batrachoididae.

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INTRODUCTION

Vocal communication is an important vehicle of social recognition in a great number of species (e.g. BEE 2004). Individual identification via acoustic features of calls is known to play a role in the recognition of kin, mates and territorial neighbours in different taxa (e.g. MYRBERG et al. 1993, AUBIN & JUVENTIN 2002). Vocal fish produce sounds that are commonly made of low-frequency pulses that vary mostly in terms of pulse number and repetition rate, and in sound duration (WINN 1964, AMORIM 2006). The most common intraspecific variation in fish sounds relates to the inverse relation between the sound dominant frequency and fish size that may mediate individual recognition based on size information (MYRBERG & RIGGIO 1985, MYRBERG et al. 1993). More elaborate individual differences in fish sounds have been described in Batrachoididae (toadfishes, BARIMO & FINE 1998, EDDS-WALTON et al. 2002, THORSON & FINE 2002) and Mormyridae (weakly electric fish, CRAWFORD et al. 1997). In both families, males are territorial, are either nocturnal or live in murky waters, and rely on their advertisement calls for female attraction (WINN 1964, CRAWFORD et al. 1997). In both families, it has been suggested that mating calls can promote individual recognition.

In this study we describe individuality of the mating sounds (boatwhistles) of nesting Lusitanian Toadfish males (*Halobatrachus didactylus* (BLOCH & SCHNEIDER 1801)) for the first time.

METHODS

Recordings of the Lusitanian Toadfish sounds were made during the mating season, in July 2001 and July 2002, from piers in two areas within the Tagus estuary, Portugal: Montijo (38°42’ N, 8°58’ W) and Barreiro (38°39’ N, 9°04’ W). Several recording sessions lasting from 5 to 10 min were carried out in both locations, with water temperature ranging between 21°-22°C. Minimum distance between recording sites within the same pier was of 4 m. Water depth in recording sites varied approximately between 0.8 and 4.0 m, depending on tide. Sounds were registered with a High Tech 94 SSQ hydrophone (sensitivity of –165 dB re 1 V/μPa, flat frequency response up to 6 kHz±1 dB) and a Sony TCD-D8 DAT. Sounds were digitised at 44 kHz (16 bit resolution) and analysed with Raven 1.2 for Windows (Cornell Lab of Ornithology, 2003).

Boatwhistles emitted by the Lusitanian Toadfish begin and end with a grunt-like phase and contain a longer tonal portion in between (DOS SANTOS et al. 2000). Ten boatwhistles per fish from a total of 13 males were analysed for the following acoustic features (Fig. 1): total sound duration (ms), duration (ms) of the initial grunt-like phase (P_1) and of the tonal phase (P_2) of the boatwhistle, pulse period (ms) in P_1 and in P_2, dominant frequency (Hz) of P_1 and of P_2, relative amplitude of P_1 in relation to P_2 (amplitude modulation). Temporal parameters were measured from oscillograms and frequency parameters from power spectra (Hamming window, filter bandwidth of 10 Hz).

RESULTS

Boatwhistles emitted by different nesting males could easily be distinguished by visual inspection of the sonogram and temporal envelope (Fig. 2) as well as through aural differences noticeable to the human ear. Different males enhance different harmonics (the first, or more frequently the second or the fourth harmonic), and show variations in the frequency modulation of the main harmonics (Fig. 2). All measured parameters showed very little intra-individual variation (i.e. coefficient of variations (c.v.) were smaller than 0.1, except for the relative duration of P_1 that had a c.v. of 0.12), and differed significantly among individuals (Kruskall-Wallis, N=130, H=94.7-118.2, DF=12, $P<0.001$). A discriminant function analysis considering these parameters, showed an overall correct classification of 95% of the sounds analysed, with the relative duration of the tonal phase (P_2), the total boatwhistle duration, and amplitude modulation being the most important variables in the model (N=130, Wilkins'λ=0.00001, $F_{96,751}$=37.334, $P<0.001$). The first 3 discriminant functions accounted for 90 % of data variation.

DISCUSSION

Our results have shown that the Lusitanian Toadfish exhibits individuality in their mating call. Boatwhistle emitted by distinct nesting males can be readily detected by the human ear and by visual inspection of their sonograms and waveforms as in the Gulf Toadfish (*Opsanus beta)* (THORSON & FINE 2002). Boatwhistles emitted by the Lusitanian Toadfish nesting males also showed little intra- and great inter-individual variation in the measured acoustic features. Overall, 95% of the sounds analysed were assigned to the correct individuals by discriminant function analysis supporting the existence of strong individuality in these mating calls.

Individuality in sounds is unusual among fish but seems widespread in the family Batrachoididae. Boatwhistles emitted by Gulf Toadfish consist of zero to three grunts followed by one to five tonal boop notes (typically 2-3 boops) lasting over a second (THORSON & FINE 2002). Boatwhistles from different individuals can be distinguished by differences in the harmonic structure (different fish emphasised different harmonics) and by boop number and duration. (THORSON & FINE 2002). Nesting Oyster Toadfish males (*Opsanus tau*) also show narrow intra-individual variation in some acoustic parameters such as sound pressure level, fundamental frequency and duration of boatwhistles (FINE 1978, BARIMO & FINE 1998). Further individual differences relate to differences in pulse repetition rate, waveform shape, and different energetic emphasis in the different harmonics (EDDS-WALTON et al. 2002). Boatwhistles in this species consist of a single tonal note (e.g. WINN 1964).

Breeding Lusitanian Toadfish males defend nests in shallow water and provide parental care to the eggs in the nest until the young are free-swimming thus defending stable territories for long periods (DOS SANTOS et al. 2000). In such stable social environments where social interactions are mainly mediated by acoustic cues (GRAY & WINN

1961, Fish 1972) it is advantageous for animals to be able to recognise their neighbours (e.g. Bee et al. 2001). In batrachoidids, mating calls are also thought to be used in male-male competition (Gray & Winn 1961, Fish 1972). The ability to recognise territorial neighbours could be by the Lusitanian Toadfish nesting males to direct less aggression towards stable neighbours. Differences in its mating calls could also provide scope for mate choice. We suggest that recognition of the identity of nesting Lusitanian Toadfish males by neighbours and mates is possible, based on individual variation in the boatwhistles.

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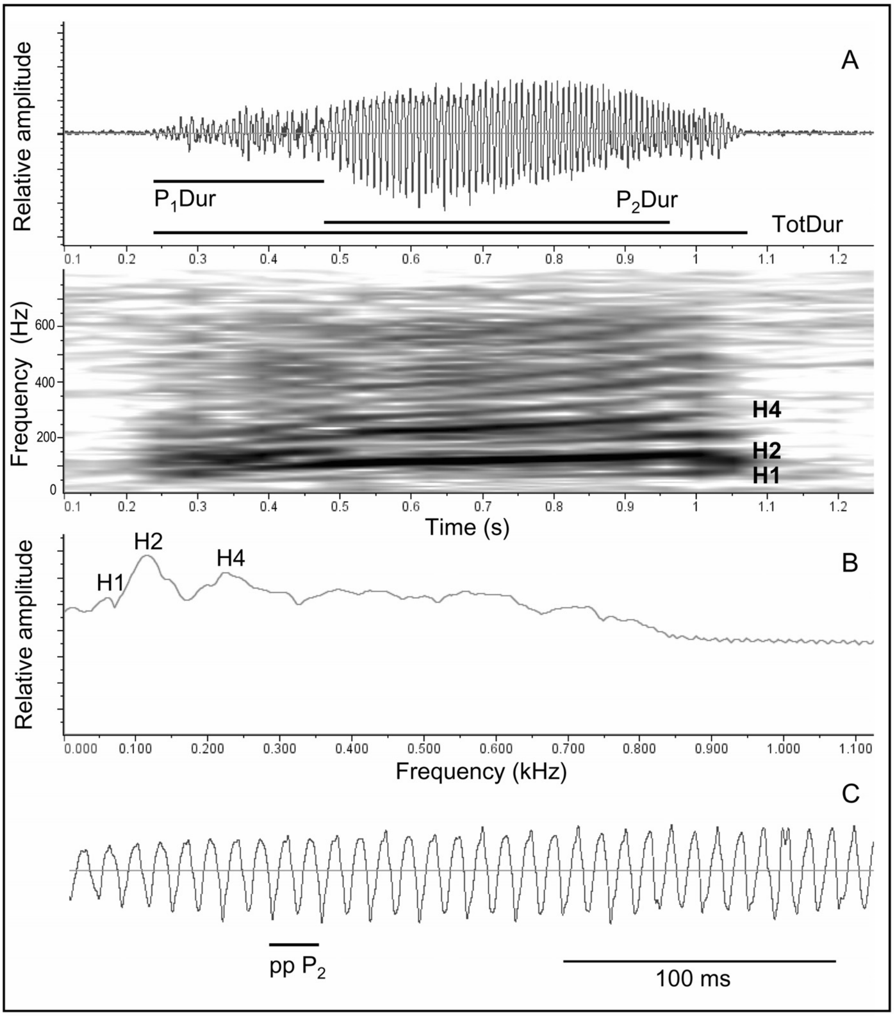

Figure 1: A – The oscillogram of a boatwhistle depicts the total sound duration (TotDur), the duration of the initial grunt-like phase (P_1Dur) and of the tonal phase (P_2Dur). The sonogram shows the fundamental frequency (H1) and the second (H2) and fourth (H4) harmonics. B- The power spectrum shows the frequency peaks of the first (H1), the second (H2) and the fourth (H4) harmonic of the boatwhistle at 58, 113 and 225 Hz, respectively. C- The expanded waveform of the tonal phase depicts the pulse period. Sonogram and power spectrum used a Hamming window and a filter bandwidth of 10 Hz.

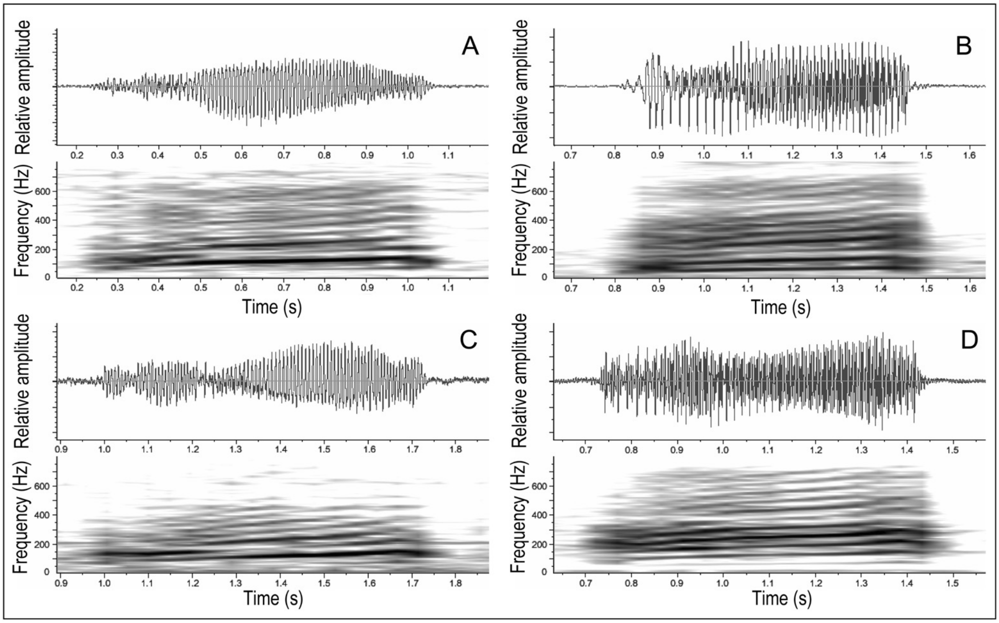

Figure 2: Oscillograms and sonograms of boatwhistles emitted by four different Lusitanian Toadfish (*Halobatrachus didactylus*) nesting males (A–D). Differences in amplitude modulation, harmonic structure, sound duration and relative duration of the tonal phase allow clear distinction between individuals. Boatwhistle B has its dominant frequency at around 60 Hz (the fundamental frequency), A and C in the second harmonic and D in the fourth harmonic. Sonogram used a Hamming window and a filter bandwidth of 10 Hz.