Behavioural Processes 128 (2016) 96–102

Contents lists available at ScienceDirect

Behavioural Processes

journal homepage: www.elsevier.com/locate/behavproc

Mate vocal recognition in the Scopoli's shearwater *Calonectris diomedea*: do females and males share the same acoustic code?

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ARTICLE INFO

Article history:
Received 29 January 2016
Received in revised form 21 April 2016
Accepted 22 April 2016
Available online 25 April 2016

Keywords:
Scopoli's shearwater
Acoustic communication
Mate vocal recognition
Playback experiments
Coding-decoding process
Sexual dimorphism

ABSTRACT

Vocal recognition is an important process allowing partners' reunion in most seabirds. Although the acoustic basis of this recognition has been explored in several species, only a few studies have experimentally tested the acoustic coding-decoding strategy used for mate identification. Here, we investigated mate recognition in the Scopoli's shearwater (*Calonectris diomedea*) by conducting playbacks of calls with modified acoustic features. We showed that females and males in a seabird species with a moderate vocal dimorphism are likely to share the same coding-decoding rule for vocal mate identification. Specifically, a disruption of call temporal structure prevented mate recognition in both sexes, in line with the parameters previously identified as supporting an individual signature. Modifications of spectral cues and envelope structure also impaired recognition, but at a lesser extent: almost half of the tested males and females were still able to recognise their partner. It is likely that this equal ability of female and male Scopoli's shearwaters to vocally recognise their partner could be found in other seabirds.

1. Introduction

In monogamous seabirds, reliable processes of mutual identification allow partners' reunion, even in dense and overcrowded reproductive colonies where confusion risk between individuals is high (Aubin and Jouventin, 1998, 2002; Charrier et al., 2001). The acoustic channel has been demonstrated as being an important means supporting this mate identification (Bretagnolle, 1996). In order to understand how individual identity can be conveyed by vocalizations, both acoustic analyses and playback experiments are required (Curé et al., 2012). On one hand, acoustic analyses can reveal the vocal parameters signalling the individual identity (coding strategy), i.e. the cues that can potentially be used by animals to identify an individual such as their mate. On the other hand, playback experiments are conducted to determine, among the range of acoustic cues signalling individual identity, the parameters that animals actually use for individual recognition (decoding strategy).

Previous studies have assessed the efficiency of vocal recognition process in several seabird species (Brooke, 1986; Curé et al., 2009; Lengagne et al., 1999, 2004; Mulard et al., 2008), and investigated the acoustic cues signalling individual signatures (Curé et al., 2009; Lengagne et al., 2000, 2001). It is now known that the coding strategies to signal individual identity can differ across seabird species and depend on both ecological and phylogenetical constraints (Curé et al., 2009, 2010; Dentressangle et al., 2012). Several studies pointed out a sexual dimorphism in vocalisations of some seabird species (Aubin et al., 2007; Brooke, 1978, 1988; Curé et al., 2009; Dentressangle et al., 2012; James and Robertson, 1985; Taoka et al., 1989). However, only a few studies have experimentally tested mate recognition in females and males separately (Dentressangle et al., 2012 for the blue-footed booby *Sula nebouxii*; Curé et al., 2009 for two species of shearwaters). In particular, there is no existing work that has investigated potential differences in the acoustic decoding strategies used respectively by males and females to recognise their mate. Focusing on the Scopoli's shearwater *Calonectris diomedea*, the present study aimed to compare the reliability of mate vocal recognition between sexes by assessing the relative responsiveness of both females and males to modifications of individual vocal signatures.

The Scopoli's shearwater, formerly considered as one of the two Cory's shearwater subspecies (Mediterranean *C. diomedea*, by opposition to the Atlantic *C. d. borealis*), is now rather treated as a separate species (*C. diomedea*, Sangster et al., 2012). It is a pelagic

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http://dx.doi.org/10.1016/j.beproc.2016.04.013
0376-6357/

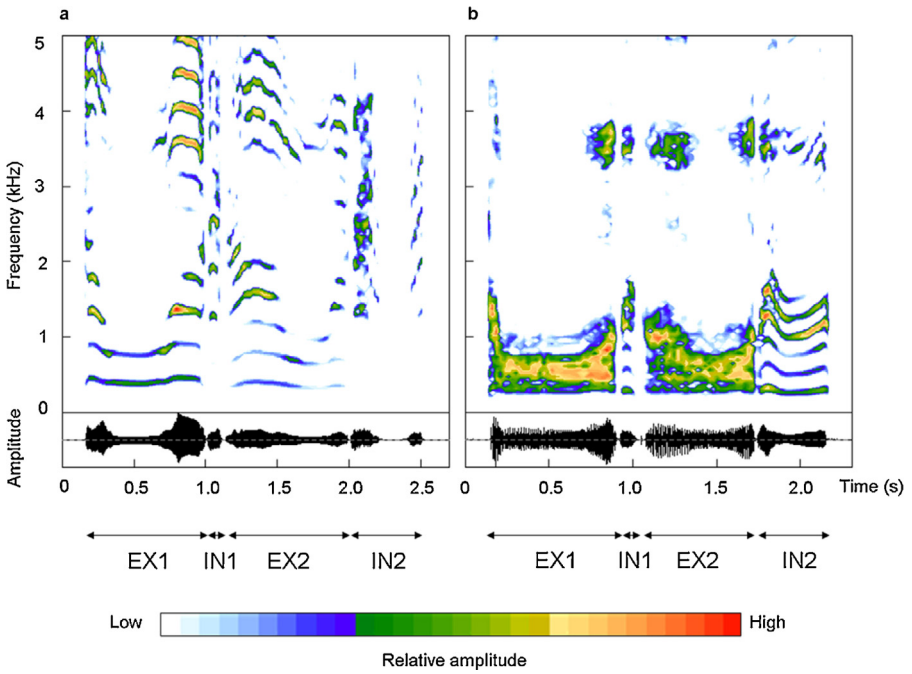

Fig. 1. Spectrograms (Hamming window; FFT length: 1024) and ocillograms of Scopoli's shearwater calls: a) male and b) female calls. In both sexes, the call is composed of two exhalant notes (EX1 and EX2) separated by a short breath (inhalant) note (IN1) and a longer one (IN2).

seabird (family Procellaridae) breeding in the Mediteranean Sea, spending most of its time at sea and coming ashore only to nest (Warham, 1990). This monogamous and highly philopatric species shows an inter-annual fidelity to the mate and to the nest site (Bradley et al., 1990; Bried et al., 2003; Mougin et al., 1999; Mougin, 2000; Ovenden et al., 1991; Rabouam et al., 1998; Thibault, 1994; Weimerskirch et al., 1985). Mate reunion occurs at night (McNeil et al., 1993) in front or within the burrow and is mediated by acoustics with both sexes producing the "major call" (Bretagnolle and Lequette, 1990; Warham, 1996). This call is composed of four broadband notes strongly modulated in frequency: two exhalant notes (EX1 and EX2) separated by a short breath (inhalant) note (IN1) and concluded by a longer inhalant note (IN2) (Fig. 1). Incubating birds usually remain silent in their burrow even when exposed to heterospecific calls and non-mate opposite-sex calls. By contrast, they vocalise in response to conspecifics same-sex calls in contexts of burrow defence and mate guarding, and also in response to their mate calls which ensures pair bond maintenance and mate identification during the breeding season (Curé et al., 2009; 2012).

In a previous acoustic analysis of Scopoli's shearwater's calls, we revealed that male and female calls differed in both the temporal and frequency domains although both sexes shared a similar overall acoustic shape (Curé et al., 2009). Specifically, the male call was higher pitched (higher fundamental frequency and more energy in higher harmonics), and also diverged in its temporal characteristics (e.g. slower amplitude modulation for the female exhalant note; difference in the duration of the call notes between sexes although the duration of the whole call remained similar). The vocal features encoding individuality in males' and females' calls included both temporal and frequency parameters (e.g., note duration, fundamental frequency values and energy spectrum features) (Curé et al., 2009). Therefore, we suspected that a combination of these various acoustic features could potentially support between-partners recognition. Since the note and inter-note durations showed the highest potential of individual coding, our predictions were that temporal features would be particularly important in this context.

Based upon these previous results, here we performed playback experiments using mate calls and modified signals derived from the mate calls, and we compared the reliability of mate vocal recognition in female and male Scopoli's shearwaters. We modified acoustic cues of the calls in the temporal, amplitude and frequency domains, and tested to what extent these modifications disrupt mate recognition in both sexes.

2. Material and methods

2.1. Ethics statement

This study was authorised by the Regione Siciliana, Assessorato Agricoltura e Foreste, Prot. 65887 dated 23/07/07.

2.2. Subjects

We conducted the present study on colonies of Scopoli's shearwaters located on Linosa (43°52N, 12°52E), a volcanic island off Sicily. There, birds breed inside burrows made by crevices in the lava formation, and are mostly concentrated on the northern side of the island (Müller et al., 2014). We conducted the fieldwork in June, during the incubation period. We selected burrows that were at least 2 m distant to the closest other nest and we marked them. Because pair mates take turns to brood the egg every few days and are seldom simultaneously present at the nest, we were able to record and test males and females separately. Since incubation relays typically occurred at night, recordings and playback experiments were performed at dark between 9pm and 4am, when birds were incubating in their burrows. As illustrated by Fig. 1, Scopoli's shearwater calls are dimorphic, providing a non-invasive and 100% reliable method to assess the sex of individuals by the mean of acoustic analyses (Bretagnolle and Thibault, 1995; Curé et al., 2009; Ristow and Wink, 1980).

2.3. Recordings and signal acquisition

We recorded the calls of 27 birds (14 females and 13 males) at the entrance of their burrows using a MARANTZ PMD 670 recorder (sampling frequency: 44.1 kHz) connected to a Sennheiser MKH70