

BIOACOUSTICS OF *ISOPHYA DOBROGENSIS*, A ROMANIAN ENDEMIC BUSH-CRICKET (ORTHOPTERA: PHANEROPTERIDAE)

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Abstract. The acoustic behavior of *Isophya dobrogensis* Kis, one of the 11 endemic Romanian Orthoptera species and one of the most vulnerable Orthoptera species in Europe, is described for the first time. Male song consists of long syllables with clear distinction between the opening hemisyllable and the closing one, comparable in structure with the audible signals of *I. costata* Brunner von Wattenwyl and *I. longicaudata* Ramme. Female acoustic response to male is one of the longest and most elaborated known within this genus.

Résumé. Le comportement acoustique d'*Isophya dobrogensis* Kis, l'une des 11 Orthoptères endémiques de Roumanie et l'une des plus vulnérables Orthoptères d'Europe, est décrit pour la première fois. La chanson du male se compose de longues syllabes avec une claire distinction entre la semisyllabe d'ouverture et la semisyllabe de fermeture, structure comparable avec les signaux audible d'*I. costata* Brunner von Wattenwyl et *I. longicaudata* Ramme. La réponse acoustique de la femelle au male est l'une des plus longues et les plus élaborées connue dans ce genre.

Key words: *Isophya*, endemism, acoustic analysis, Popina Island.

INTRODUCTION

Genus *Isophya* Brunner von Wattenwyl is the second largest of Palaearctic Orthoptera, with 89 species known so far and 45 species present in Europe (Eades et al., 2012). The *Isophya* species populate Southern and Eastern Europe, the Caucasus and Asia Minor, many species having a small range size with specific topographic and habitat affinities (Bauer & Kenyeres, 2006). Acoustic communication is widespread amongst the Orthoptera, being the most obvious component of their ethology. Antagonistic to morphological traits, the structure of acoustic signals shows clear dissimilarities when comparing close-related species. The main function of the song is to transmit the information between the partners during their pair-forming behavior (Orci & Heller, 2004). Usually, males stridulate instinctively and females decide to approach or even respond acoustically. In most of the *Isophya* species, the pair formation is achieved during an acoustic duet of the male and female (Orci, 2007; Orci et al., 2010).

There are 17 *Isophya* species currently known to occur in Romania and 4 of them are endemic: *Isophya harzi* Kis, *I. dobrogensis* Kis, *I. sicula* Orci, Szövényi & Nagy and *I. ciucasi* Iorgu & Iorgu.

Regarded as the only endemic Orthoptera species in Romanian lowland (Kenyeres et al., 2009), *Isophya dobrogensis* is one of the most vulnerable *Isophya* species in Europe, as it is known only from the Popina Island. This small island is located in the Northern part of Razelm Lake, Danube Delta Biosphere Reserve and has a surface of slightly less than 1 square kilometer. The dry habitat is about 0.65 square kilometers and the rest of the island is a marshy area with reed beds. From the dry habitat the species seems to prefer only the margins of the island, with loess

substratum, and not the vegetation installed on the outcrops of Triassic limestone that form most of the surface.

MATERIAL AND METHODS

In the spring of 2007 and 2011, on the occasion to visit Popina Island, several individuals have been collected alive for acoustic analysis. All material was collected from the North-Western part of the island, from dense vegetation covering the abrupt slopes.

All individuals have been recorded in laboratory conditions, using the digital recorders SONY ICD SX56 and EDIROL R-09HR, the latter being equipped with stereo microphones having a sound frequency response between 20-40.000 Hz. Resulting wave sound files (24 bits, 96 kHz) were analyzed with Audacity 2 software.

Song terminology follows Heller et al. (2004): *syllable* - the sound produced by one complete up (*opening hemisyllable*) and down (*closing hemisyllable*) stroke of the forewings; *impulse* - the highly damped sound impulse arising as the impact of one tooth of the stridulatory file.

Photos were taken with a Canon EOS digital camera equipped with a Canon 100 mm 1:1 macro lens. Insects' wing movements during the song have been video recorded at 60fps with the same camera. Scanning Electron Microscope pictures were taken with a Tescan Vega SEM.

RESULTS AND DISCUSSIONS

Order Orthoptera
Suborder Ensifera
Family Phaneropteridae

Isophya dobrogensis Kis, 1994

Material examined. 4 ♂♂, 2 ♀♀, 10.05.2007, 44°58'23"N, 28°58'33"E, 5 m a.s.l.; 3 ♂♂, 1 ♀, 11.05.2011, Popina Island (Razelm lake, Romania), 44°58'21"N, 28°58'31"E, 8 m a.s.l.; 7 ♂♂, 5 ♀♀, 07.06.2011, Popina Island (Razelm lake, Romania), 44°58'19"N 28°58'30"E, 11 m a.s.l. (Fig. 1)

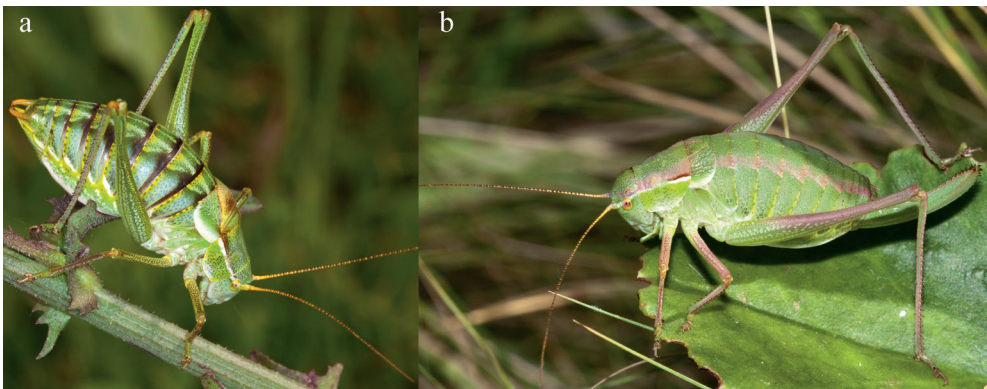


Fig. 1 - Habitus of *Isophya dobrogensis*: a, male; b, female (07.06.2011, Popina Island, photo I. Șt. Iorgu).

Acoustic recordings. Isophya dobrogensis: 2 ♂♂, 10.05.2007, Popina Island (air temperature 20°C); 6 ♂♂, 3 ♀♀, 07.06.2011, Popina Island (air temperature 26°C); *Isophya costata*: 1 ♂, 08.06.2012, Lipova, Arad county (air temperature 23°C); *Isophya longicaudata*: 1 ♂, 14.06.2012, Cheile Dobrogei, Constanța county (air temperature 28°C).

Bioacoustics. The calling song consists of long syllables, clearly formed of 2 distinctive parts. The first part, an opening hemisyllable, is a compact series of 60-100 impulses lasting for 300-420 ms. After a short pause of 90-200 ms, the insect closes the tegminae and this part of the syllable has an elaborate assembly of 3-6 small groups of impulses. Each group consists of 2-6 impulses and the total duration of the closing hemisyllable is 330-650 ms. The total duration of a syllable is 730-1100 ms. In the opening hemisyllable, the sound amplitude slowly raises in the first quarter and then fades out gradually in the closing hemisyllable (Figs 2 a, b; 3 a).

In this species, we recorded one of the longest known female answers to male song known in the genus *Isophya*. Female acoustic response occurs after males' closing hemisyllable, as it was described also in *I. modesta* Frivaldszky (Orci & Heller, 2004). It is formed of a variable series of 9-27 impulses, recorded for a period of 3.4-8.2 s. Sometimes, this impulse series tends to form a group of 8-13 impulses in the beginning, lasting 301-596 ms; the following impulses are widely spaced and suggest a form comparative in oscillographic structure with a male song. Generally, the female response delay after male's song was 300-400 ms, occurring only after male closing hemisyllable and never interleaving (Fig. 2 c).

The sound frequency in male song ranges between 13-45 kHz with the highest peak at about 20 kHz in the opening hemisyllable and 13-23 kHz, having a maximum at 17 kHz, in the closing hemisyllable. In females, the most intensive frequency is situated in the interval 10-27 kHz, highest peak at 20 kHz (Fig. 4).

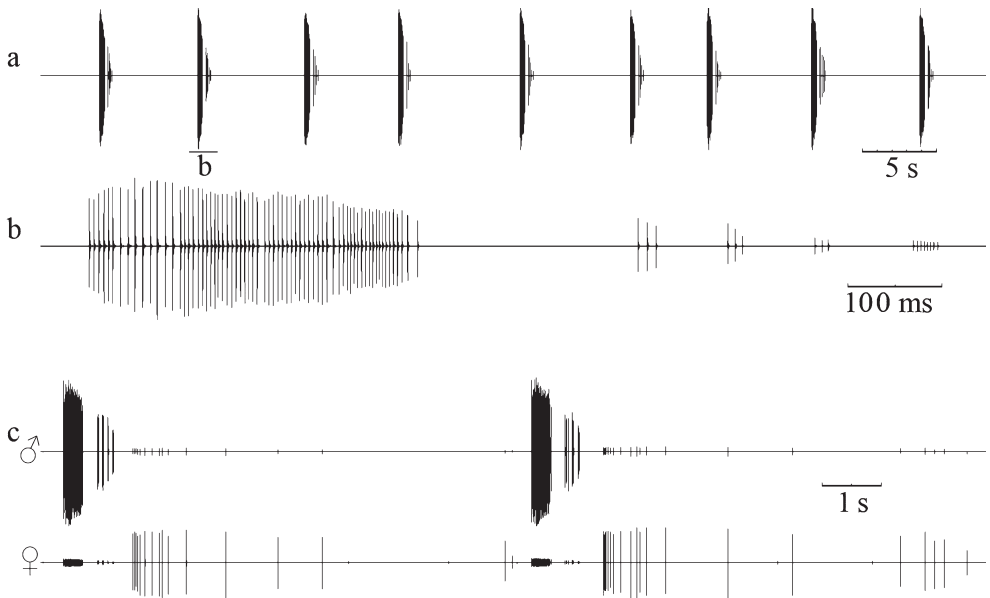


Fig. 2 - Oscillographic analysis of the acoustic signals in *Isophya dobrogensis*: a, male calling song; b, male detailed syllable; c, male-female duet.

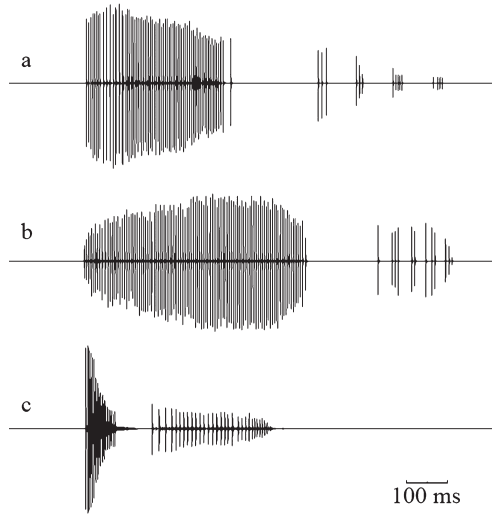


Fig. 3 - Detailed oscillographic analysis of the acoustic signals in *Isophya* males: a, *Isophya dobrogensis*; b, *Isophya costata*; c, *Isophya longicaudata*.

Stridulatory file in the examined males is 4-4.6 mm long and bears 261-275 teeth. In females it consists of 2 distinct small areas with many stridulatory pegs (Fig. 5).

The interesting song of *Isophya dobrogensis*, consisting of a main impulse series and a terminal impulse series, is similar to that of several other *Isophya*. Orci & Heller (2004) discussed this type of song for *Isophya modesta*, comparing it with that of *I. brunneri* Retowski, *I. speciosa* Frivaldszky, *I. amplipennis* Brunner von Wattenwyl and *I. costata* Brunner von Wattenwyl. From all these species, the song of *I. costata* is the closest in oscillographic structure to *I. dobrogensis*. In *I. costata*, the main part of a syllable tends to be longer, consisting of 102-110 impulses lasting for 490-553 ms, followed after 160-191 ms by a series of 5-13 after-clicks lasting for about 157-192 ms (Fig. 3 b). However, all sounds are produced when *I. costata* closes the tegminae, contrary to *I. dobrogensis* that produces distinct sounds when it opens and then closes the wings. Regarding the sound production mechanism, the song of *Isophya dobrogensis* is remarkably similar to the one produced by *I. longicaudata*: a short opening hemisyllable (72-81 ms with 20-27 impulses) and a longer closing hemisyllable (270-305 ms with 27-33 impulses), divided by a 75-109 ms time interval (Fig. 3 c).

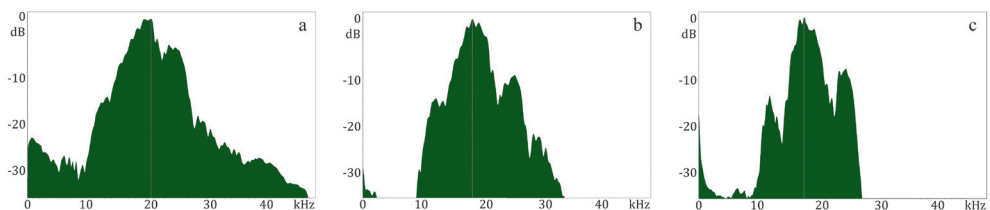


Fig. 4 - Spectrographic analysis of the acoustic signals in *Isophya dobrogensis*: a, male opening hemisyllable; b, male closing hemisyllable; c, female song.

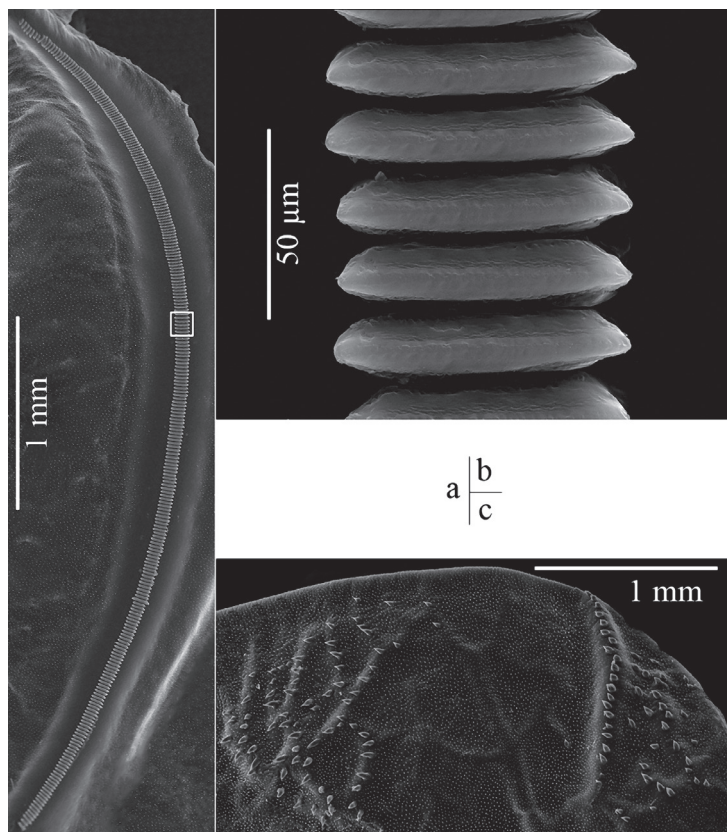


Fig. 5 - Stridulatory file in *Isophya dobrogensis*: a, male; b, detailed section from a; c, female (SEM photos).

The number of 250-280 teeth on the stridulatory file of *I. costata* (Heller et al., 2004) is very similar to *I. dobrogensis*.

Based on male sound structure, wing morphology and number of teeth in the stridulatory file, the species *Isophya dobrogensis* should be placed in the *I. costata* species group, as defined by Warchałowska-Śliwa et al. (2008).

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BIOACUSTICA LA *ISOPHYA DOBROGENSIS*, UN COSAȘ ENDEMIC PENTRU ROMÂNIA (ORTHOPTERA: PHANEROPTERIDAE)

REZUMAT

Este descris pentru prima dată comportamentul acustic al cosașului *Isophya dobrogensis* Kis, una dintre cele 11 specii endemice din România și una dintre cele mai vulnerabile specii de Orthoptera din Europa. Cântecul masculului constă în silabe lungi, cu distincție clară între semi-silaba de deschidere și cea de închidere, comparabil ca structură cu semnalele auditive ale speciei *Isophya costata* Brunner von Wattenwyl și *Isophya longicaudata* Ramme. Răspunsul acustic al femelei la sunetul produs de mascul este printre cele mai lungi și elaborate cunoscute în acest gen.

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