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Isophya sicula sp. n. (Orthoptera: Tettigonioidea), a new, morphologically cryptic bush-cricket species from the Eastern Carpathians (Romania) recognized from its peculiar male calling song

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Abstract

The morphology and pair-forming acoustic signals of *Isophya sicula* **sp. n.**, a new phaneropterine bush-cricket species from the Eastern Carpathians (Romania) is described. The species is morphologically similar to *I. posthumoidalis* and *I. camptoxypha*, but the male calling song differs clearly from the songs of those species. The male calling song is a long series of evenly repeated, very short syllables. Syllables are much shorter than in *I. camptoxypha*, and the song is composed from only one syllable type differently from *I. posthumoidalis*, where the male calling song is composed of two syllable types. Pair formation is achieved during an acoustic duet. The delay of female response (40–70 ms) is shorter than in *I. camptoxypha* and *I. posthumoidalis*. Basic descriptive statistics of sonometric and morphometric characters of the new species as well as SEM photos of the male stridulatory file and female stridulatory bristles are presented.

Key words: acoustic signal, stridulation, oscillogram, spectrogram, male-female duet, Isophya posthumoidalis, Isophya camptoxypha

Introduction

Isophya presently includes 90 species in one of the most species-rich genera of the bush-cricket subfamily Phaneropterinae (Eades & Otte 2010; Braun 2010). *Isophya* species are distributed in the Western Palaearctic with a diversity centre in Anatolia. Morphological uniformity often renders species-level taxonomy and identification difficult (Ramme 1951; Bei-Bienko 1954; Harz 1969). Unfortunately, males lack sclerotised internal genitalia, that are used successfully to differentiate species in other groups of Orthoptera. Interestingly, the amplitude modulation pattern of the male calling songs is rather diverse and generally provides us the most useful and reliable differential characters (e. g. Heller 1988; Orci *et al.* 2005; Chobanov 2009). Since the main function of acoustic communication in Orthoptera is to provide conspecific males and females to recognise and find each other, acoustic signals are important components of the species specific mate recognition system of these animals (e. g. Walker 1957; Spooner 1968; Paul 1976; Zhantiev & Dubrovin 1977; Helversen & Helversen 1983; Dobler *et al.* 1994; Orci 2007). Therefore, it is not only effective (see e. g. Walker 1964, Heller 1988, Ragge & Reynolds 1998, Kleukers et. al 2010) but also relevant to use acoustic signal characters when examining the species level taxonomy of these insects.

In the latest taxonomic review of the Western and Central European species of the genus, Heller *et al.* (2004) pointed to a number of problematic issues calling for further investigation. One of those issues is the interesting morphological variation observable in the case of *Isophya camptoxypha* (Fieber), especially in the Eastern part of its distribution range (Kenyeres & Bauer 2005; Iorgu *et al.* 2008) as it had already been noted by Kis (1960). Since information about the male calling songs of those eastern populations of *Isophya*

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camptoxypha was not available we decided to examine the acoustic signals of the populations occurring in the Romanian Carpathians and Central Transylvanian Mountains (Munţii Apuseni). During that explorative work in the Harghita Mountains we unexpectedly discovered a new species, *Isophya sicula* **sp. n.**, with similar morphology to *Isophya camptoxypha* and *I. posthumoidalis* Bazyluk, but with a strikingly different male calling song. In this paper we describe that species including morphological and bioacoustic characterisation and discuss its relationship with its closest relatives.

Material and methods

Collection of specimens. The only known population of the new species was found near the village Harghita-Bâi, on the Mountain Harghita-Ciceu (Eastern Carpathians, Romania). There is a ski-lift line leading from the northern-eastern edge of Harghita-Bâi to the mountaintop of Harghita-Ciceu (Fig. 5/A, B). The ski-lift line run above a forest clearing where we found an abundant population of *Isophya sicula* **sp. n.** (geographic coordinates: N 46º 23' 27.61", E 25º 37' 37.86", 1400–1730 m a.s.l.). Specimens could be collected from *Vaccinium* L. sprouts and *Rubus* L. shrubs using a sweep net or by visual searching. After the discovery of the first few specimens of the new species on 30th July 2004, the type locality was visited and specimens were collected several times from 2005 to 2009. Young adults and last instar nymphs was collected during the middle of June, however, imagines could be found even at the end of July. In captivity these bush-crickets could be kept on *Urtica dioica* L., *Medicago sativa* L., *Coronilla varia* L., *Galium verum* L., *Plantago lanceolata* L.

Bioacoustic examination. The calling song of 11 males were recorded and analysed. Female response song could be examined only in 1 female. Song recordings were made using the following sound recording equipment: an electret condenser microphone (Monacor ECM 920) or a condenser microphone (Bruel Kjaer ½ inch) with a Nexus signal conditioning amplifier or a Pettersson D240X ultrasound detector was connected to a DAT recorder (Sony TCD-D8) or to a solid-state recorder (M-Audio MicroTrack 24/96). Using 48 kHz sampling frequency and 16 bit resolution in DAT recordings or 96 kHz sampling frequency and 24 bit resolution in MicroTrack recordings. Oscillographic and spectrographic analysis were made using the software Adobe Audition 1.5.

Bioacoustic terminology. The bioacoustic terminology of this study is adopted mainly from Ragge and Reynolds (1998).

Calling song: spontaneous song produced by an isolated male.

Syllable: the song produced by one opening-closing movement cycle of the tegmina.

Impulse: a simple undivided transient train of sound waves (here: the highly damped sound impulse arising as the impact of one tooth of the stridulatory file).

Click: an isolated distinct impulse.

Functional unit of the song: the shortest part of the song, which contains all necessary song elements and in the appropriate order to elicit female response.

Song characters measured. The stridulatory songs of European bush-crickets are generally amplitude modulated signals (Heller 1988; Ragge & Reynolds 1998). Therefore our description of the song of *Isophya sicula* focuses on rhythmic characters which can be measured precisely on oscillograms. We chose characters which were expected to be useful for specific differentiation after over viewing the songs of morphologically related taxa, and also characters that contribute significantly to the general appearance of the signal. The following oscillographic characters were measured:

Syllable repetition period (SRP): the time elapsed from the beginning of a syllable to the beginning of the next syllable.

Syllable duration (DS): the time elapsed from the beginning of first impulse to the end of last impulse of the main impulse series of a syllable.

Number of impulses per syllable (NI): the number of impulses of the main impulse series of the syllable.

Delay of after-clicks (Dac): the time elapses from the first impulse of the main impulse series of the syllables to the first impulse of the after-click(s).

Delay of female response (Dfr): the time elapses from the first impulse of the main impulse series of the preceding male syllable to the main impulse of the female response.

Morphometric measurements. Morphological measurements were made in 11 males and 10 females. A detailed description of the examined morphometric characters can be found in Orci *et al.* (2005) with a schematic drawing of the measurement points. Here again we chose characters to measure which are expected to be useful for comparing/differentiating *Isophya sicula* to/from closely related species.

Results

Isophya sicula Orci, Szövényi & Nagy sp. nov.

Type material. Holotype, male (dry, pinned specimen) labelled: "Isophya sicula, Harghita Bâi (Hargitafürdő), 2009. VI. 17., leg. Orci, K. M. & Szövényi, G.". Paratypes, 4 males (one of them dry, pinned specimen the others in ethanol), 2 females (one dry, one in ethanol), all of them with the same data as in holotype. All specimens of the type material are deposited in Collection of Small Insect Orders, Hungarian Natural History Museum, Budapest, Hungary. A CD containing a sound recording of the calling song of holotype and paratype males is deposited also in the collection of HNHM.

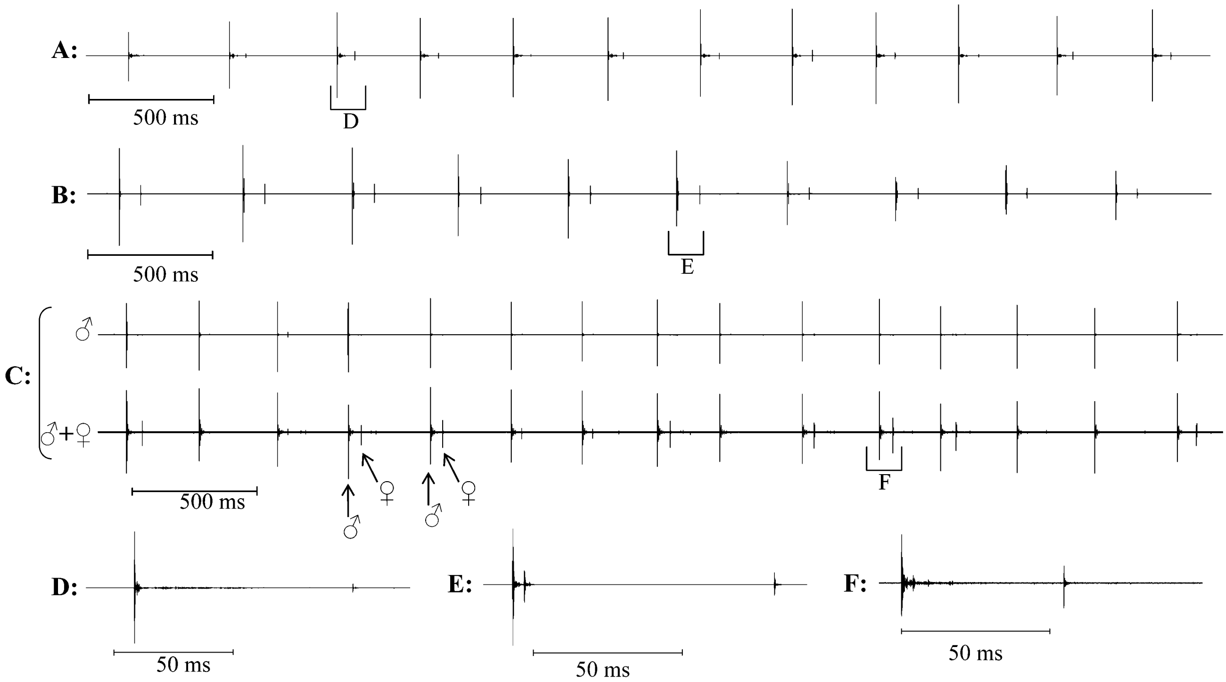

FIGURE 1. Oscillograms of the male calling song (A, B, D, E) and male female duet of *Isophya sicula* **sp. n.** (C, F). Syllable sequences at a larger time scale are shown in A, B, and C; single syllables at a more fine time resolution are presented in D, E, F. Ambient air temperature during the recording was 24.5 ºC in the case of A, D; 21.6 ºC in B, E; 26.5 ºC in C, F.

Male calling song and male-female duet. The male calling song of *Isophya sicula* **sp. n.** is a long sequence of syllables (Figs. 1/A, B and Fig. 6/A) produced by tegmino-tegminal stridulation. The duration of a continuous song is rather variable (from a few seconds to several minutes) with apparently accidental termination. A syllable consists of a main impulse series containing typically 1–2 (rarely 3) impulses and 0–1 after-clicks (Figs. 1/D, E and Fig. 6/D). Impulse repetition period in the main impulse series (if there are two or three impulses) is 3–5 ms. Peak amplitude of impulses in the main impulse series is much higher than that of the after-click. Syllables are repeated at an even repetition rate throughout the whole syllable sequence. Syllable repetition period (SRP) proved to be dependent of air temperature (in the range of 21–26 Celsius degrees SRP = 849,75 – 20,26 * T; where T is for air temperature in Celsius degrees, N=11, Pearson product moment correlation between SRP and T was: r = - 0,635, p = 0,036). See Table 1 for basic descriptive statistics on the oscillographic features of the male song. The carrier wave has a wide-band frequency spectrum (Fig. 2) containing detectable components from 15 to 55 kHz and showing an amplitude maximum around 25 kHz. Therefore the male calling song sounds as a rather faint click-series to the unaided human ear and can be heard only from very short distance (1–2 m).

The female response song contains one high amplitude impulse (Fig. 1/F) and occasionally some additional, hardly detectable low-amplitude impulses following or preceding the main one after/by 10–20 ms. Female response can be expected after every syllable of the male (Fig. 1/C) with a response delay of 40–70 ms (60 responses of one female was measured: minimum response delay was 39 ms, maximum 85 ms, 90% of responses had a delay between 40–70 ms).

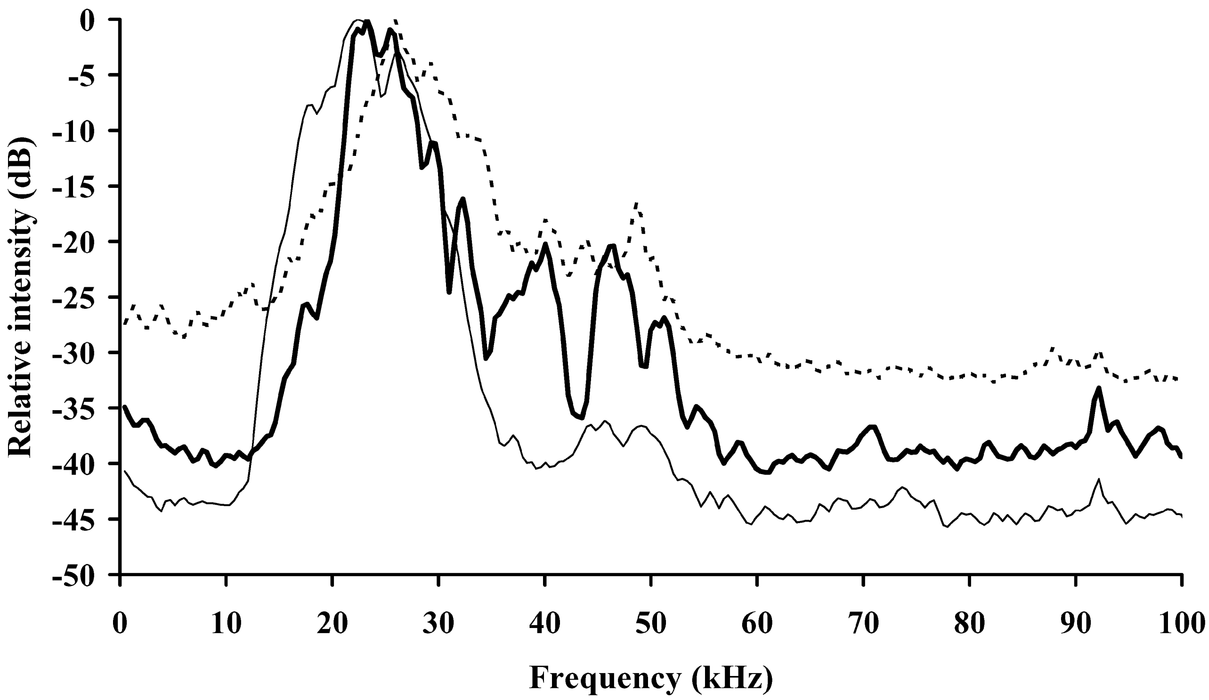

FIGURE 2. Power spectra of the male calling song of *Isophya sicula* **sp. n.** (**—**), *Isophya camptoxypha*(−) and *Isophya posthumoidalis*(…). (FFT size 1024 points, window function Blackmann-Harris)

Morphology. Male (Fig. 3/A, C, D and Fig.5/C, D): Head with fastigium verticis at base nearly as wide as half of scapus, relatively prolonged slightly tapered frontward; with dorsal groove. Pronotum 3.3–3.7 mm long, lateral carinae nearly parallel in prozona, broken at traverse sulcus, abruptly widen at the middle of length of metazona and becomes nearly parallel in the posterior part of metazona; anterior and posterior edges of pronotum moderately concave; in lateral view, dorsal surface of pronotum moderately concave, raised in metazona; ventral edge of paranota nearly straight; caudal margin of paranota slightly curved and passing into hind margin of pronotum. Maximum height of paranota about half the length of pronotum. Tegmina short and narrow. Visible length of elytra nearly as long as pronotum, approaching or reaching caudal margine of 1st abdominal tergite. Cu2 of tegmen swollen, its length 1/2 of caudal margin of pronotum, not reaching the right margin, right margin of left tegmen forms an obtuse angle at the distal end of Cu2, speculum quadrangular. Stridulatory file 1.6–1.8 mm in length, with 48–60 teeth (Fig. 4/A). Hind femur 3.6–4.5 times long as pronotum, without ventral spines. Epiproct 2–2.5 times as wide as long. Cerci 2.0–2.4 mm long, covered by fine, short hairs, gradually narrow distalwards, distal 1/3 gradually and moderately incurved, apex of cerci rounded, with 1 triangular shaped black denticle. Subgenital plate moderately elongated, reaching the 3/4 length of cerci in dorsal view, narrowed apically with a relatively deep triangular incision and acute lobes on its caudal margin. Coloration green with fine dark spots (Fig. 5/C), in approximately 30 % of the examined specimens with two brick-red bilateral stripes on dorsal side from pronotum to the end of abdomen (Fig. 5/D). Antennae yellowish brown, fastigium greenish brown, disc of pronotum green, lateral carinae with narrow reddish and white stripes. Tegmina brownish with light brown costal field and green margins with yellowish lateral stripe. Legs greenish or brownish with small darker spots.

For descriptive statistics of 9 morphometric characters of males see Table 2.

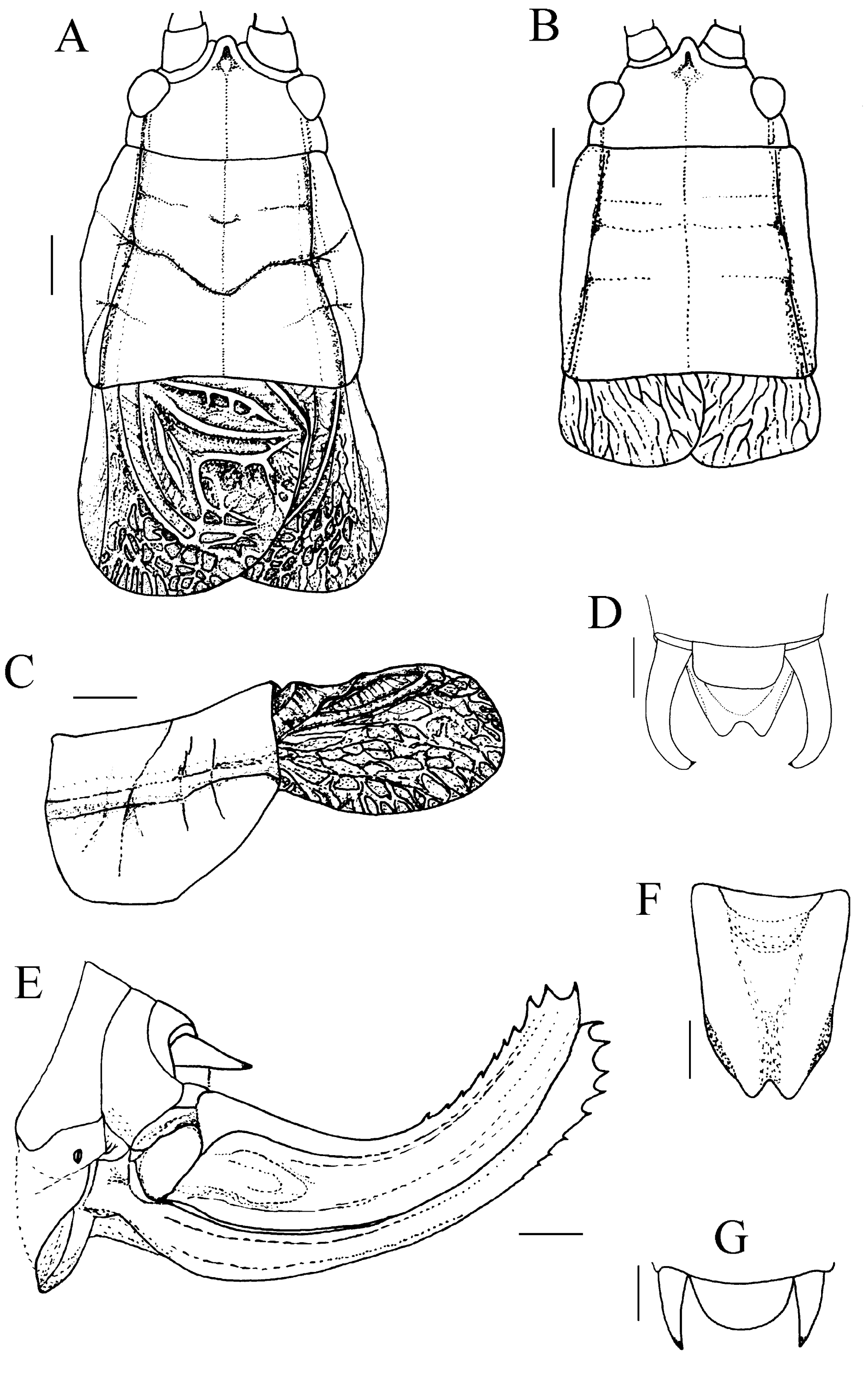

FIGURE 3. Drawings illustrating the typical eidonomy of *Isophya sicula* **sp. n.** male and female. A, male head, pronotum and elytra from above, B, female head, pronotum and elytra from above, C, male pronotum and elytra in profile, D, male external genitalia, E, ovipositor, F, subgenital plate of female, G, cerci and epiproct of female

TABLE 1. Descriptive statistics for the basic rhythmic parameters of the male calling song of *Isophya sicula* **sp. n.** Abbreviations: SRP: syllable repetition period, DS: duration of syllable, NI: number of impulses in the main impulse series of the syllable, Nac: number of after clicks, Dac: delay of first after click (all duration values are given in milliseconds), T: ambient air temperature during sound-recording, in each character for each specimen mean values of 15 measurements are given.

Specimen	SRP	DS	NI	Nac	Dac	T
1	305.33	1	1	1.07	66.73	24.8
2	372.07	1.13	1	0.6	102.22	24
3	403.53	3.6	1.87	0.93	93.21	23
4	330.27	2.13	1.93	2.07	64.33	22.9
5	332.20	1.8	1.8	-	-	25.7
6	331.53	1.33	1.4	0.67	79.3	25.4
7	353.73	2.4	1.93	1	69.93	24.5
8	374.67	-	-	1	59.46	24.8
9	398.33	-	-	1.47	56.67	24.6
10	324.6	-	-	-	78.75	24.8
11	428.93	3.27	2	1.07	80.47	21.6
Mean	359.56	2.08	1.62	1.10	75.11	24.19
Std. Dev.	39.02	0.97	0.42	0.44	14.61	1.22
Minimum	305.33	1	1	0.6	56.67	21.6
Maximum	428.93	3.6	2	2.07	102.22	25.7

TABLE 2. Descriptive statistics for some morphometric characters of males of *Isophya sicula* **sp. n.**

	N	Mean	Minimum	Maximum	Std. Dev.
Width of head	11	3.54	3.4	3.7	0.102
Length of pronotum	11	3.57	3.3	3.7	0.142
Width of pronotum (caudally)	11	4.14	3.6	4.4	0.269
Length of left elytrum	7	3.89	3.7	4.1	0.135
Width of left elytrum	10	3.12	3	3.3	0.103
Length of stridulatory file	4	1.66	1.6	1.77	0.079
Number of stridulatory pegs	5	53.40	48	60	4.775
Length of hind femur	11	15.77	13.5	17	1.142
Length of cercus	11	2.20	2	2.4	0.1

Female (Fig. 3/B, E, F, G and Fig.5/E): Head roughly as in male. Pronotum 3.6–4.3 mm long, with straight lateral carinae, dorsal surface slightly concave, caudally moderately widening from the almost straight frontal margin until its moderately concave caudal margin; without conspicuous sulcus, paranota similar to those of male. Tegmina about third the length of pronotum, approaching or reaching the anterior margin of 1st abdominal tergite, roughly quadrangular, edges more or less rounded. Right tegmen with two fields of stridulatory bristles on its dorsal surface near inner margin as in Fig. 4/D. Hind femur 3.7–4.5 times as long as pronotum, without ventral spines. Epiproct semicircular. Cerci short, 1.3–1.7 mm long, covered by fine, short hairs, slightly bent, spine-like. Subgenital plate rounded, triangular like. Ovipositor relatively short, 2.1–2.5 times as long as pronotum (8.1–9.3 mm), gradually curving and narrowing distalwards; with 7–10 spines on dorsal margin and 7–9 spines on ventral margin, gonangulum ellipsoid. Coloration of head, body and legs similar to that of male (Fig. 5/E). Tegmina light brownish with yellowish lateral edges. For descriptive statistics of 11 morphometric characters see Table 3.

Diagnosis. Male song is a long syllable sequence composed of one type of syllable repeated at an even repeatition rate (140–200 syllables per minute at 21–26 C air temperature). Syllables consist of a main impulse-series of 1–2 (3) impulses and 0–1 after-clicks. Fastigium verticis at base half as wide as scapus, elytra reatively short and narrow in male, the length of Cu2 ½ of the width of caudal margin of pronotum, right margin of left elytrum with a rounded obtuse angle at the distal end of Cu2, stridulatory file contains 48–60 pegs (see Fig. 4/A). Cerci of male 2.0–2.4 mm long, gradually narrow distalwards, distal 1/3 gradually and moderately incurved, apex of cerci rounded, with 1 triangular shaped black denticle. Ovipositor 8.1–9.3 mm.

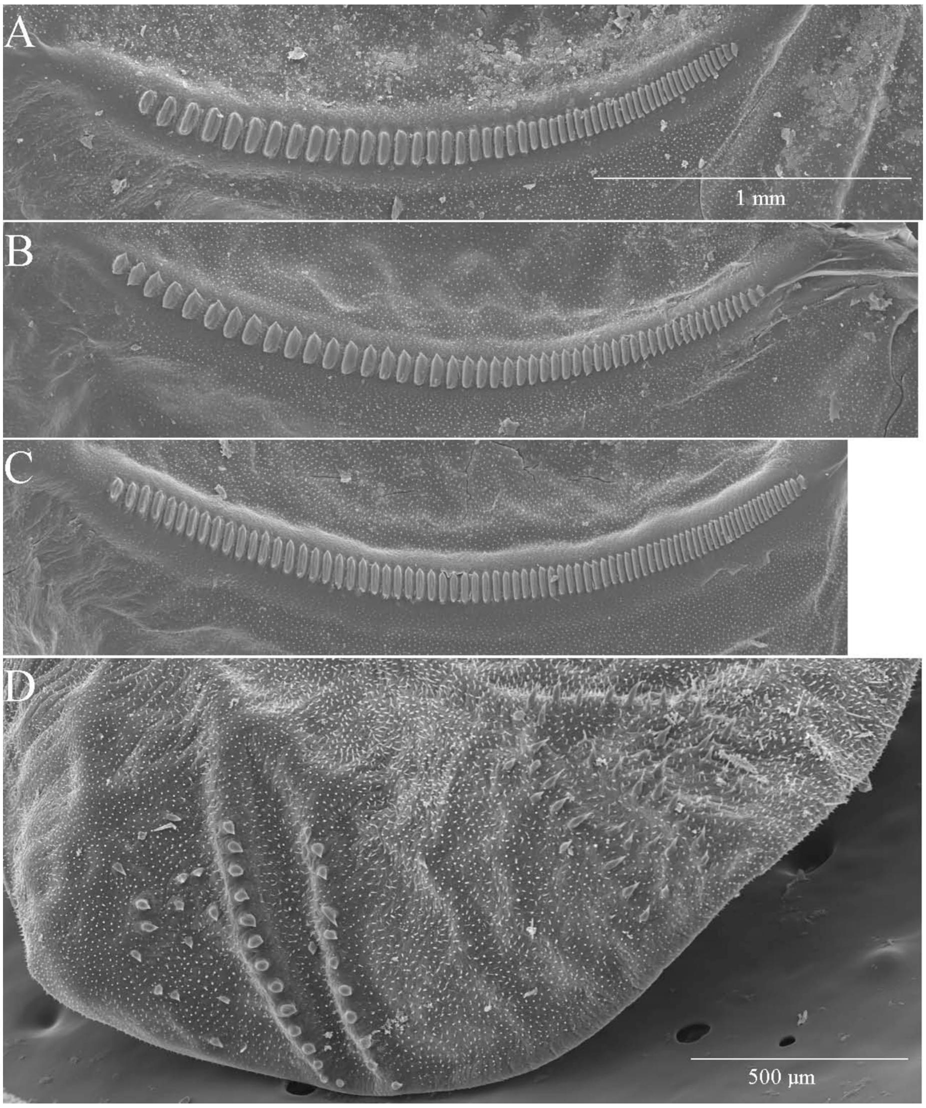

FIGURE 4. SEM photos of the male stridulatory file of *Isophya sicula* **sp. n.** (A), *Isophya posthumoidalis* (B), *Isophya camptoxypha* (C) and stridulatory bristles on the dorsal surface of the inner quartile of right elytrum of an *Isophya sicula* **sp. n.** female. Scale is the same for A, B, C, but different in D.

Habitat (Fig. 5/A, B). The type locality of the new species is on the southern slope and plateau-like peak of the mountain Harghita-Ciceu, situated at the southern end of the volcanic mountain range Harghita (inner arch of Eastern Carpathians, Transylavania, Romania). Habitat of this species was found along the edge and in the small clearings of the Piceaetum excelsae forest belt (1350 – 1660 m a.s.l.) and also on the rocky plateau-like peak (1700–1730 m). Characteristic elements of the vegetation structure of the habitat are *Juniperus* L. and *Vaccinium* shrubs among the scattered *Picea excelsa* L. trees and a dense grassy vegetation of 18-40-60 cm hight among stones and rocks (5–15 % cover). Characteristic species of the Orthoptera assemblage in which *Isophya sicula* was found were *Euthystira brachyptera* (Ocskay, 1826), *Myrmeleotettix maculatus*

(Thunberg, 1815), *Chorthippus pullus* (Philippi, 1830), *Miramella* Dovnar-Zapolskij, 1932 sp., *Decticus verrucivorus* (Linnaeus, 1758).

Etymology. The specific epithet sicula (Latin) refers to the name of a group of local residents in the region of type locality, the Székely people.

FIGURE 5. Photos of the habitat on Mountain Harghita-Ciceu at 1350 m a.s.l in June, 2005 (A) and at 1700 m a.s.l. on 30th July 2004 (B) and specimens of *Isophya sicula* **sp. n.** (C, D, E).

TABLE 3. Descriptive statistics for some morphometric characters of *Isophya sicula* **sp. n.** females.

	N	mean	minimum	maximum	Std. Dev.
Width of head	10	3.95	3.7	4.1	0.118
Length of pronotum	10	3.95	3.6	4.3	0.227
Width of pronotum (caudally)	10	4.61	4.3	5	0.208
Length of left elytrum	10	1.73	1.3	2.1	0.236
Length of subgenital plate	10	1.08	1	1.2	0.063
Width of subgenital plate	10	3.16	2.8	3.4	0.184
Length of hind femur	10	15.61	14.1	17.1	0.919
Length of ovipositor	10	8.93	8.1	9.3	0.365
Narrowest width of ovipositor	10	1.86	1.6	2	0.126
Length of body	10	18.85	16.2	21.8	1.576
Length of left cercus	10	1.5	1.3	1.7	0.115

Discussion

Regarding its morphology *Isophya sicula* **sp. n.** is related very closely to *Isophya* posthumoidalis and *Isophya camptoxypha*. Those three Isophya species (*I. sicula*, *I. posthumoidalis* and *I. camptoxypha*) can be recognised amongst the Isophya species known to occur in Europe from the following morphological features: Fastigium verticis around half as wide as scapus, the right margin of left elytrum in males curves with an obtuse angle at the distal end of Cu2, cerci have a gradually incurving apical area, stridulatory file contains 50–80 pegs, ovipositor shorter than 9.5 mm (Heller *et al.* 2004) . Within those three species *I. sicula* can be distinguished from *I. camptoxypha* on the basis of its narrower disc of left elytrum. However we could not find any differential morphological character for distingushing *I. posthumoidalis* and *I. sicula*. Thorough morphometric examination of larger series of specimens would be needed to see if the two species can be indentified using multivariate statistics similarly to *Isophya stysi* Cejchan and *Isophya modestior* Brunner von Wattenwyl, where discriminant analysis proved to be a powerful tool for calculating classification functions that can be used reliably for the identification of specimens (Orci *et al.* 2005).

The male calling song of *Isophya sicula* is surprisingly simple in its oscillographic structure. In the genus *Isophya* the most common syllable structure consists of a main impulse series followed by a few, isolated after clicks (Heller 1988, 1990). The song of *Isophya sicula* can be derived for that basic pattern by shortening the main impulse series to 1–2(3) impulses. With those extremely short syllables the male calling song strongly differs from that of *Isophya camptoxypha*, however the syllable repetition rate of that two species is similar (compare Fig. 6/A and B). Comparing the song of *I. sicula* to the song of *I. posthumoidalis* it can be seen that the two species use acoustic signals with different basic structure. While the song of *Isophya sicula* contains only one type of syllable and syllables are repeated evenly and females response can be expected after every syllable of the male (Fig. 1/C) , the song of *I. posthumoidalis* (Fig. 6/C, F) is composed of two syllable types: type A and B, which are performed in a pattern that can be formulated as AAA…A – BAA…A – B and so on (… means a variable number of A syllables and – means a longer inter-syllable interval) (see Heller et al 2004 for more details) and in that species female response song can be expected only after the B syllables (Orci *et al*. 2008). Interestingly the syllables of *I. sicula* are similar to the B-type syllables of *I. posthumoidalis* (compare Fig. 6/D to the first syllable in Fig. 6/F). Spectral features of the male calling song are rather similar in the three species (Fig. 2) which may be a consequence of the similar dimensions of the male stridulatory apparatus. Overviewing the relevant literature (Zhantiev & Dubrovin 1977; Zhantiev & Korsunovskaya 1986, 1990; Heller 1988, 1990; Ingrisch 1991; Heller *et al.* 2004; Sevgili *et al.* 2006; Chládek 2007; Chobanov 2009) we found that the male calling song of *Isophya sicula* with its extremely short syllables and relatively fast and even syllable repetition rate differs from all known male song patterns described in the genus.

Male calling songs present only the signaller's side of an acoustic species-specific mate recognition system. Acoustic signal recognition at the receiver's side, in females, is of equal importance. We believe that *I. sicula* males would get no response from *I. camptoxypha* females because females of *I. camptoxyha* showed unimodal preference function against syllable duration with a maximum response ratio at 50 ms and nearly 0% response at 10 ms syllable duration (Orci 2007); therefore we expect no response to *I. sicula* song that contains typically syllables of 1–3 ms duration. On the other hand we do not know song preferences of females in *I. sicula*, and therefore cannot estimate their responsiveness to *I. camptoxypha* male songs. Nevertheless, even if *I. sicula* females would reply to *I. camptoxypha* males, those males would unlikely recognise them as conspecific females, because in *I. campoxypha* the delay of female reply is much longer (150–220 ms from the end of main impulse-series of male syllable (Orci 2002)) than in *I. sicula* (40–70 ms). In *I. posthumoidalis* the female preferences are unknown to us. Nevertheless in that species the male song is much more complex and syllable repetition rate is much higher than is *I. sicula* (compare oscillogram A and C in Fig. 5); moreover our preliminary data on the female response latency of *I. posthumoidalis* (100–150 ms contrary to 40–70 ms in *I. sicula*) suggest that *I. posthumoidalis* and *I. sicula* males would not recognise female responses from the other species as conspecific signals. We expect that those differences make communication impossible between *I sicula* and *I. posthumoidalis*.

With its 1–3 ms long main impulse series the syllables of *I. sicula* are amongst the shortest syllables known for an *Isophya* species (see e. g. the song of *I. brunneri* Retowski in Zhantiev and Dubrovin 1977). Syllable duration may be under stabilising selection, if it is a critical character for species recognition, however two groups of directional selection pressure may also act on it: sexual selection and natural selection (Greenfield 2002; Bailey 2003). Sexual selection generally force males to produce longer, more costly, more complex signals containing more information for females and rival males. Contrary to that natural selection often favour signal types that are shorter and more simple, that way the signaller save energy and reduce the risk of being detected by predators or parasites. Those general patterns of signal evolution suggest that the syllables of *I. sicula* may have become very short under intensive natural selection and/or relatively light pressure of sexual selection. However, Heller (1990) described a possible scenario in which sexual selection favours shorter signals: males may chime into each other's call obscuring or disabling female response for the rival's call. Short male signals with short female response latency are less susceptible to such a rival interference.

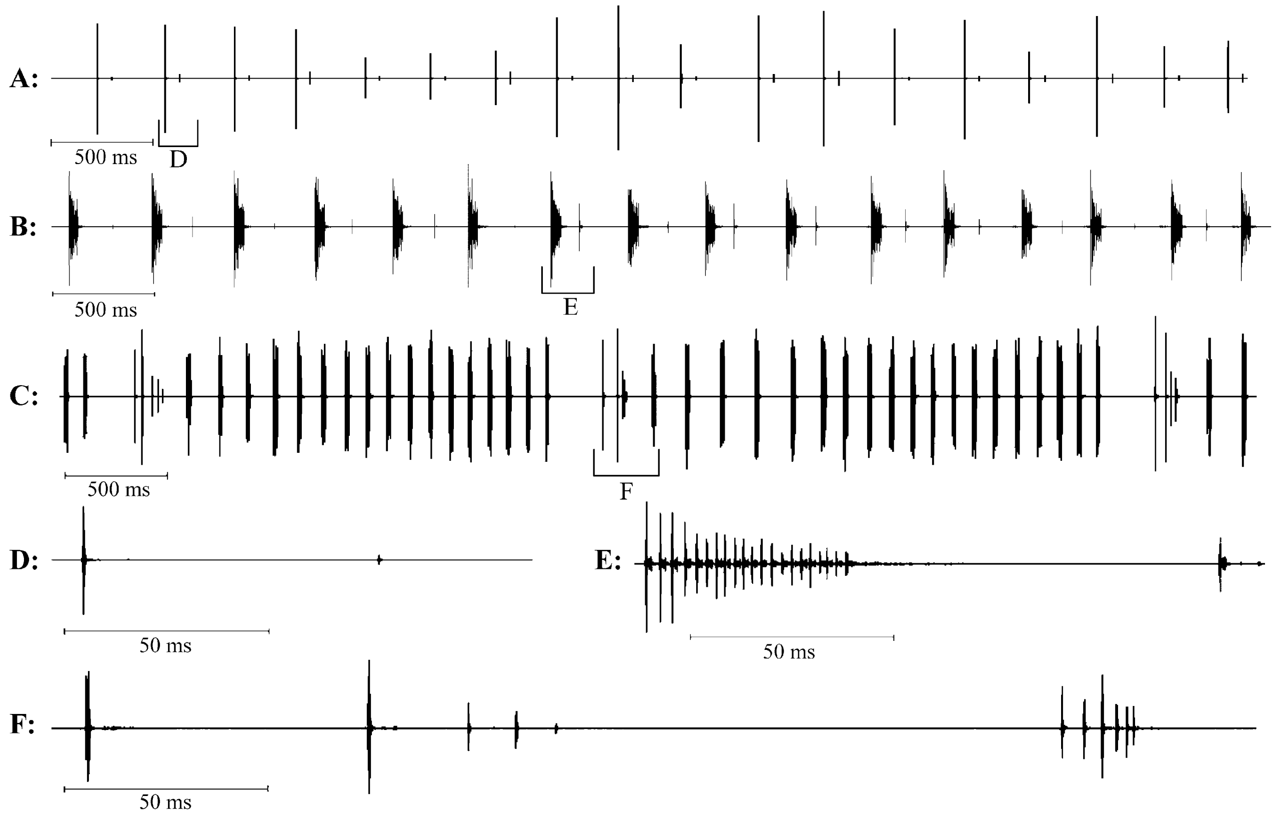

FIGURE 6. Oscillograms of the male song of *Isophya sicula* **sp. n.** (A, D)(specimen from the type locality: Harghita-Cicue Mounain (E Carpathians, Romania)), *Isophya camptoxypha* (B, E)(recorded from a specimen collected from Mecsek Mountains (SE Hungary)) and *Isophya posthumoidalis* (C, F)(specimen collected from Maramureş Basin (NW Romania)). Syllable sequences at a larger time scale are shown in A, B, and C, and single syllables at a more fine time resolution are presented in D, E, F (in F two syllables can be seen: one B and one A type syllable) Ambient air temperature during the recordings was 24.8 ºC in the case of A, D; 26.2 ºC in B, E; 23.4 ºC in C, F.

The delay of female response in *Isophya sicula* is rather short (40–70 ms). That finding is in accordance with the general positive correlation between male signal duration and the duration of female response latency (Bailey & Hammond 2003). Its very instantaneous nature can be perceived, if we compare it to the latency of startle response of flying insects detecting the sonar of a hunting bat. For example in the bush-cricket *Neoconocephalus ensiger* (Harris) behavioural latency of startle response is around 45 ms (Libersat & Hoy 1991), in the beetle *Euetheola humilis* Burmeister it is 40 ms for stimuli at hearing threshold (Forrest *et al.* 1995). However, it is not the shortest latency amongst phaneropterine bush-crickets: Heller and Helversen

(1986) report 15 ms for *Andreiniimon nuptialis* (Brunner von Wattenwyl) and Robison *et al.*(1986) measured 20–30 ms in *Leptophyes punctatissima* (Bosc).

Our study is only the first step to acquire information about the biology of this interesting new species. It would be very important to gather more data on its geographic distribution, especially to see whether or not this species occurs sympatrically with *I. camptoxypha* or *I. posthumoidalis*. There are several examples of endemism with very restricted distribution ("spot-like" endemisms) in the European Orthoptera (Kenyeres *et al.* 2009), and presently it seems *I. sicula* is one of them, however since *I. sicula*, *I. camptoxypha* and *I. posthumoidalis* are difficult to distinguish from each other regarding their morphology bioacoustic examination of *I. camptoxypha*-like populations in the neighbouring mountain ranges will be necessary to have a more complete picture of its distribution. Other interesting subjects to study are acoustic species recognition and female song preferences in this species. Those results could shed some light on the selection pressures acting on *I. sicula* male song and would help us to have some idea on its evolution. Moreover a molecular genetic examination of this species and its relatives would be of fundamental importance to see its phylogenetic relations to the other species of the genus.

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