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In copertina: L'apparato per le registrazioni ultrasoniche, che include il microfono Ultramic 250 e il computer portatile Asus Netbook.

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CESARE BRIZIO, GUIDO PAGLIANO & FILIPPO MARIA BUZZETTI

THE BURROWING BUZZ OF *SPHEX SP.* EXTENDS TO THE INAUDIBLE RANGE

Abstract - Cesare Brizio, Guido Pagliano & Filippo Maria Buzzetti - The burrowing buzz of *Sphex sp.* extends to the inaudible range.

In recent years, several species of Orthopterans were field-recorded by authors 1 and 3 thanks to an innovative, low cost USB microphone with a sampling frequency of 250 kHz. In August 2019, during an acoustic exploration for Orthopterans, author 1 intercepted sounds from a burrow in the soil, from which a Sphecid wasp – here tentatively determined as *Sphex funerarius* (Gussakovskij, 1934) – emerged and was photographed in suboptimal conditions during the recording session. While the quality of the digital audio tracks was satisfactory, the collection of the buzzing specimen proved unfeasible. We provide a concise review of scientific literature about burrowing behaviour in Sphecidae, in particular covering those sources that describe the buzzing sound associated with the burrow excavation, and propose a comprehensive review of the audio samples obtained, including envelopes, spectrograms and frequency analyses, and revealing the previously unreported extension well into the ultrasonic domain, up to 70 kHz and above, of the buzzing sound emitted by burrowing Sphecoidea.

Keywords: Hymenoptera - Sphecidae - Sardinia - Bioacoustics.

Riassunto - Cesare Brizio, Guido Pagliano & Filippo Maria Buzzetti - Il ronzio di scavo di Sphex sp. si estende alla gamma del non udibile.

Negli ultimi anni diverse specie di ortotteri sono state registrate sul campo dagli autori 1 e 3 grazie a un innovativo microfono USB a basso costo con una frequenza di campionamento di 250 kHz. Nell'agosto 2019, durante una prospezione acustica per ortotteri, l'autore 1 ha intercettato i suoni da una tana nel terreno, da cui è poi emersa una vespa Sfecide – qui provvisoriamente determinata come *Sphex funerarius* (Gussakovskij, 1934) – e fotografata in condizioni non ottimali durante la sessione di registrazione. Mentre la qualità delle tracce audio digitali è soddisfacente, la raccolta dell'esemplare autore del ronzio si è rivelata impossibile. Forniamo una breve rassegna della letteratura scientifica sul comportamento fossorio negli Sphecidae, in particolare coprendo quelle fonti che descrivono il suono ronzante associato allo scavo delle tane e proponiamo una revisione completa dei campioni audio ottenuti, inclusi sonogrammi, spettrogrammi e analisi di frequenza, rivelando bene l'estensione

precedentemente non segnalata nel dominio degli ultrasuoni, fino a 70 kHz e oltre, del suono ronzio emesso da questo Sfecide fossorio.
Parole chiave: Hymenoptera - Sphecidae - Sardegna - Bioacoustica.

Introduction

Previous bioacoustics studies by the authors in the same geographic area (including Brizio & Buzzetti 2014; Brizio 2015) demonstrated on the field the effectiveness of low cost USB microphones capable of recording ultrasounds thanks to high sampling frequency (250 kHz), the consistency of such recordings with those obtained with a 96 kHz audible band digital recorder, and the possibility to identify different species on the basis of their song, as well as to derive novel information from an analysis of high frequency components of the songs, previously unreported in the scientific literature: an observation limited to audible frequencies, or to the 0-48 kHz range provided by 96 kHz recordings, may deliver incomplete or misleading results.

In this short paper, the same techniques cited above are applied to the bioacoustic characterization and to the analysis of the buzzing sounds by a Sphecid wasp. From the photos taken on the occasion, it's prudent to abstain from a species-level determination, even though the pictured and recorded female specimen most probably is a *Sphex funerarius* (Gussakovskij, 1934). For those reasons, we will hereinafter refer to the specimen as to *cf. Sphex funerarius*.

Being not equipped for capture during the recording phase, author 1 was unable to prevent the specimen from leaving the area, and two subsequent visits to the same burrow did not provide opportunities to collect the same specimen previously recorded. In the following pages, the analysis of the buzzing song of *cf. S. funerarius* will reveal its previously unreported extension, well into the ultrasonic domain.

Even though this report will not delve into biological, ethological or ecological considerations, the importance of bioacoustic, species-specific material in biodiversity studies cannot be overestimated (Sugai & Llusia 2018), regardless to the nature of the material – intraspecific or interspecific communication, echolocation, or – as in our case – the side effect of a specific behaviour.

In particular, authors 1 and 3 in recent years strived to provide an objective description of the bioacoustic phenomena they investigated, thus overcoming the inaccuracies caused by anthropocentric constraints (such as the description of just their audible components). We deem equally important to describe with increased accuracy also the well-know burrowing sounds of a Sphecid wasp digging.

Material and methods

Material described in Tab. 1 includes four acoustic recordings from Italy, Sardinia, Gutturu Mandara, Fluminimaggiore (South Sardinia Province), Latitude 39.446617 (39°26’47,82”), Longitude 8.444887 (8°26’41,59”), ~30 m asl (Fig. 1), taken on 24 August 2019:

– Three recordings obtained at 96 kHz sampling frequency.
– One recording at 250 kHz sampling frequency.

Audio samples examined	Duration (mm:ss)	Sampling frequency	Interval Analyzed in figures 6 - 16
Ultramic Sphecidae Buzzing Sound _20190824 204635.wav	1:17.931	250 kHz	10.953 to 12.648 55.123 to 1:00.455
Sphex_funerarius_ZOOM0026.WAV	1:04.996	96 kHz	0:4.00 to 0:16.00
Sphex_funerarius_ZOOM0027.WAV	50.578	96 kHz	0:21.70 to 0:33.70
Sphex_funerarius_ZOOM0029.WAV	1:01.640	96 kHz	0:27.00 to 0:37.00

Tab. 1 - List of the audio samples examined in this paper.

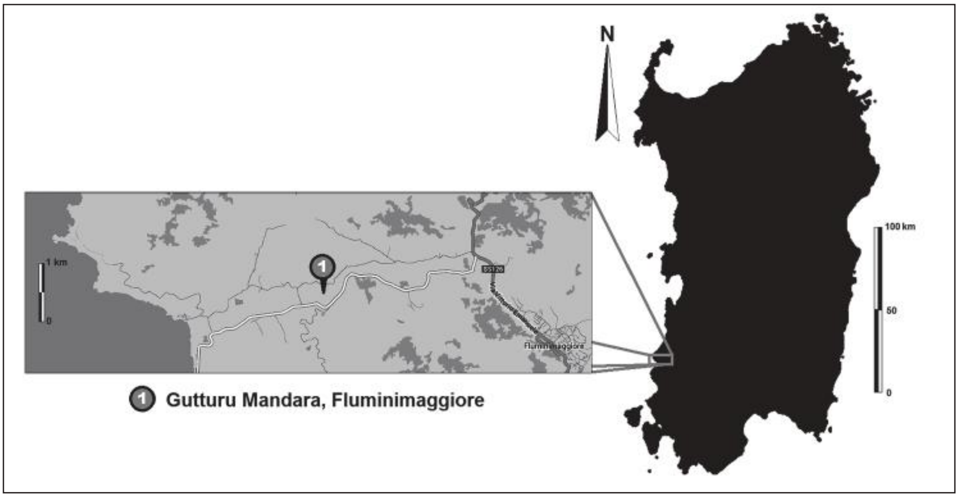

Fig. 1 - Map of the recording station of Gutturu Mandara, Fluminimaggiore, Southern Sardinia - Latitude 39.446617 (39°26’47,82”), Longitude 8.444887 (8°26’41,59”), ~30 m asl.

To ensure consistency with previous analyses (Brizio & Buzzetti 2014; Brizio 2015), the same methods have been applied here. All the audio material was obtained by field recording. Specimens were not captured nor recorded in constrained conditions.

Acoustic stereophonic recordings were taken at 16 bit, 96 kHz sampling frequency, thus covering frequencies up to 48 kHz. The audio samples where obtained in the field, in windy conditions. Having observed no meaningful pattern in the lowest frequency range, to improve the clarity of the successive analyses and illustrations, an 18th order Chebyshev Type 1 high pass filter was applied, with cut-off frequency between 400 Hz and 450 Hz. Recording equipment included a Zoom H1 handheld digital Micro-SD recorder, coupled with a self-built stick stereo microphone whose head includes two Primo EM-172 capsules mounted in the prime focus of a 30 cm PET parabola (Fig. 2). The back-to-back arrangement of the capsules maximizes left/right stereo channel separation, a feature very useful in the process of locating with precision unseen specimens while recording: it was by this specific feature that it become possible to observe the stereo channel decoupling that will be described and shortly discussed later.

Ultrasound monophonic recording at 250 kHz sampling frequency was performed via a Dodotronic Ultramic 250 microphone connected via 30 cm USB cable to an Asus Eee PC 1225B notebook personal computer (Fig. 3), using SeaWave software by CIBRA-University of Pavia's "Centro Interdisciplinare di Bioacustica e Ricerche Ambientali". Sound pressure is expressed in dB Full Scale.

Sound pressure envelopes, spectrograms and frequency analysis diagrams were generated by Adobe Audition 1.0 software. To give more evidence even to the faintest significant spectral components, and to improve the readability of frequency / volume analyses, screenshots were contrast-enhanced with Adobe Photoshop Elements 4.0 by a procedure involving in sequence: colour removal, image inversion, brightness and contrast adjustment, shadows / highlights adjustment. Those interventions did not affect the accuracy of the rendering.

The illustrations of frequency analyses were generated with a scan of the entire audio sample (see table 1, column "Interval analysed") and with an FFT size of 8192 byte, capable to render a smoother and clearer picture. All the software cited was operated under Windows 7 64-bit operating system.

Brizio & Buzzetti (2014) address in more detail some technical requirements of Ultramic 250 and propose a specific operating protocol to ensure comparability between Ultramic recordings and audio range recordings available in literature. Brizio (2015) describes in more detail the challenges of ultrasound field recording and the necessity to record as near as possible to the singing animal, to avoid the attenuation of faint high-order harmonic components.

It's well known (Brizio & Buzzetti 2014; Brizio 2015) that Ultramic 250, a device optimized for the inaudible range, has a suboptimal frequency response in the audible frequencies. The quick monitoring performed before initiating the Ultramic recording, showed that at default (100%) microphone volume setting the recording would have been saturated and hence unusable. The unavoidable decision to lower the recording volume to avoid saturation caused a further, selective decrease

Fig. 3 - The ultrasound-recording apparatus including the Ultramic 250 microphone and the Asus Netbook portable computer.

Fig. 2 - The self-built parabolic stick microphone used for audible band recordings. In the insert, detail of the microphonic head with the Primo EM172 capsules arranged back-to-back.

Fig. 4 - The recording station of a possible *Sphex funerarius*, Gutturu Mandara, 24.VIII.2019.

Fig. 5 - Tip of the abdomen of a possible *Sphex funerarius* while buzzing from its burrow, Gutturu Mandara, 24.VIII.2019.

Fig. 6 - Habitus of a possible *Sphex funerarius*, Gutturu Mandara, 24.VIII.2019.

Fig. 7 - Two details of the head of a possible *Sphex funerarius*, Gutturu Mandara, 24.VIII.2019.

of sensitivity in the audible band, that on the contrary is excellently covered by the 96 kHz recordings obtained via the Primo EM-172 parabolic microphone: as a consequence, both the 96 kHz and the 250 kHz recordings should be considered to get a realistic representation of the acoustic emissions described in this paper.

Due to the very wide band received, Ultramic recordings are affected by both anthropogenic / technogenic sources (background noise structure, including narrow peaks attributable to house alarms is shown in Fig. 14) and by natural ultrasound sources such as bats, whose echolocation calls affect a band centred at around 80 kHz, the same frequency range where sound emissions attributable to *cf. Sphex funerarius* fade out. In that respect, we cannot convincingly state that the feeble components above 80 kHz can be attributed to the digging wasp.

The audio band (96 kHz sampling frequency) recordings were particularly well-suited for the time domain analyses (sound pressure envelopes) and allowed to draw more precise conclusions about the distribution of the audible frequencies, while the recording that includes the inaudible range provided an exhaustive representation of the whole frequency range encompassed by the audio emissions.

Photographs were taken by a Sony DSC-HX60 compact digital photo camera, in the dim light of the impending darkness, around 21:00 CET. The unexpected encounter with the very mobile wasp and the suboptimal lighting affected the quality of the pictures and, coupled with the unavailability of a captured specimen, prevented a sure determination.

Results

Bioacoustic remarks

Frequency analyses of the stereophonic recordings taken in the audible range at 96 kHz show a regular succession of bands, whose sound pressure decreases geometrically, proportional to the decrease in sensitivity of the microphone. The main bands, on average 4-5 kHz wide, are centred at 2 kHz and 6 kHz and the subsequent ones are spaced by around 3 kHz up to 30-33 kHz.

On the other side, frequency analyses of the Ultramic recordings – while confirming the existence of a more or less regular sequence of peaks up to 15 kHz, merge higher frequencies in two very wide bands centred at around 24 kHz and 50 kHz, whose intensity is comparable with the lower frequency, more pronounced first peaks. Secondary peaks up to 30-33 kHz mark the same cusps shown in the audible band recordings.

Fig. 8 to 18 are self-explanatory and describe clearly the patterns and the structure of the buzzing sounds recorded at an air temperature around 24 °C.

The sound emissions observed consisted of diverse echemes, emitted quite regularly as well as irregularly. Two kind of echemes were observed:

– Echemes indicatively lasting 0.2-0.5 seconds (maximum observed duration around 750 milliseconds, with more than 100 unitary pulses) emitted with a more or less regular rhythm, at an indicative rate of 100 to 150 per minute, in cycles of varying durations indicatively ranging from 5 to 10 seconds or more, most probably corresponding with the treatment of different portions of the pedotrophic chamber walls.

– Occasionally, a very loud and short buzz / syllable was emitted, lasting down to 60 milliseconds, and with around 20 unitary pulses.

The limited duration of the encounter, totalling less than two minutes, and the necessity to activate two different devices (for audio and ultrasound recording, respectively) impeded author 1 to optimize the volume setting for those louder and isolated syllables, whose unexpected intensity in some cases saturated the recording and prevented their reliable frequency analysis.

In some echemes, it's possible to observe the concurrence in each channel of two separate phase-shifted pulse trains, as shown in Fig. 8. While the asynchronous activation of the paired sets of wing muscles is the most probable cause of the two concurrent pulse trains observed in Fig. 9, and also probable in Fig. 10, its appearance in each stereo channel makes impossible to ascertain whether an antero-posterior or latero-lateral separation of the two concurrent sources of vibration exists.

The high directional selectivity of the parabolic microphone, the very short recording distance (under 20 cm) and the structure of the microphonic head allowed to observe a frequency shift between the sounds recorded by left and right capsule,

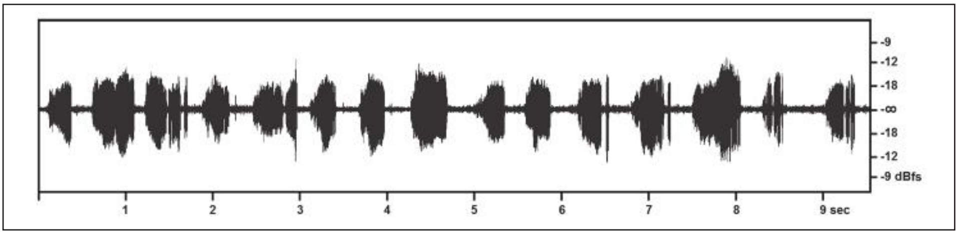

Fig. 8 - Sound pressure envelope of a 96 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019. Left Channel.

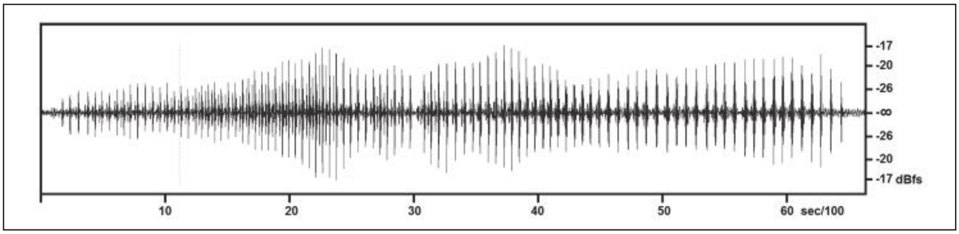

Fig. 9 - Detail of the sound pressure envelope of one of the longest echemes in a 96 kHz audio sample by *Sphex funerarius*, Gutturu Mandara, 24.VIII.2019. Left Channel - Two distinct asynchronous pulse trains can be observed in the first part of the echeme.

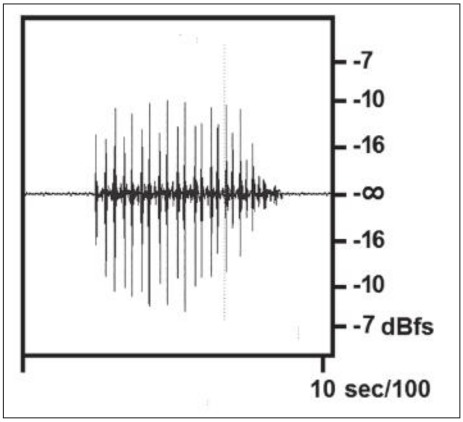

Fig. 10 - Detail of the sound pressure envelope of one of the shortest and loudest echemes in a 96 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019. Two concurrent pulse trains seem apparent.

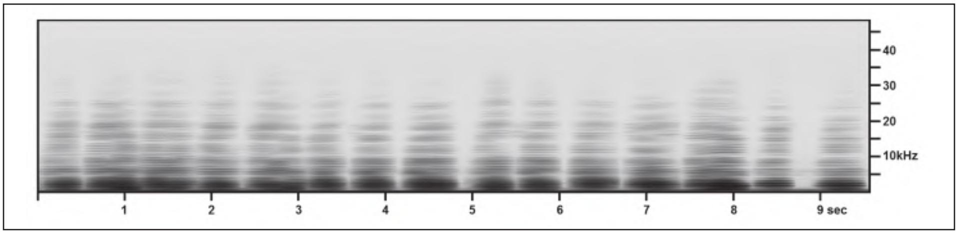

Fig. 11 - Time/frequency spectrogram of a 96 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019. Left channel.

but the suboptimal recording conditions (burrowing, barely visible specimen and impending darkness) made impossible to ascertain the relative orientation of, on the one hand, the longitudinal axis of the body of the singing specimen and, on the other hand, the vertical plane of the microphonic head, that delimits left and right audio channel.

So, again, while it's confirmed that a spatially oriented characterization of the emission is present in the frequency analyses, and even though it's plausible that each capsule caught the asynchronous vibration of a separate set of wing muscles, it's impossible to say whether the relatively higher frequency profile received by the right side capsule could be attributed to e.g. the anterior or the rightmost side of the animal.

We would like to further clarify that the sound pressure envelopes and the frequency analyses represent two different, even though most probably deeply related, phenomena: at sound pressure level, the shift of two or more pulse trains on the time axis reveals the concurrent and independent activity of more than one frequency generator – a phenomenon that can be equally observed on each audio channel and that may point at the concurrent activation of more than one muscle.

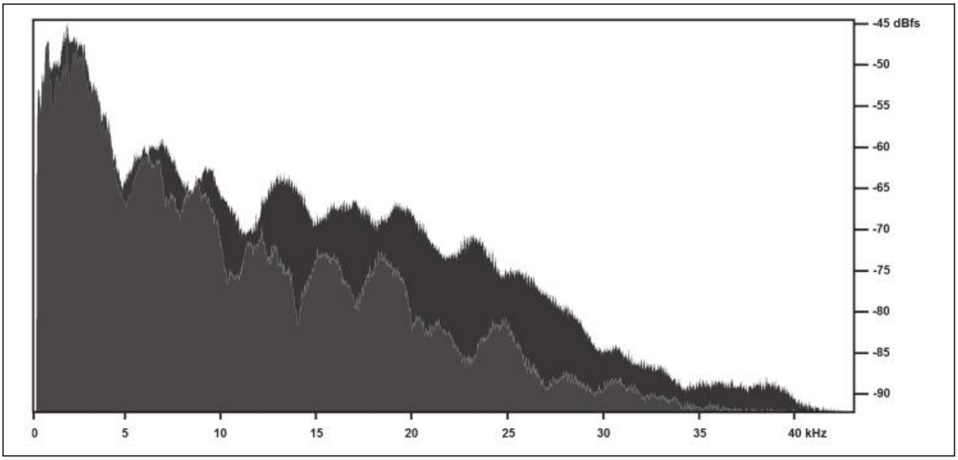

Fig. 12 - First frequency/volume analysis of a 96 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019. A decoupling between left channel (foreground) and right channel (background) can be observed, with frequency peaks shifted to higher frequencies in the right channel. See text for comments.

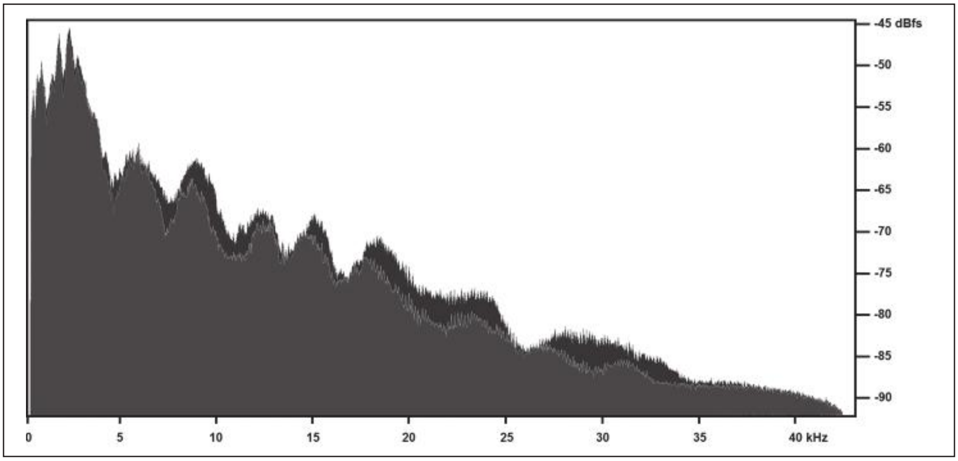

Fig. 13 - Second frequency/volume analysis of a 96 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019.

At frequency analysis level, by scanning a definite amount of time, the different profiles of the left and of the right channel frequency/volume analysis shows that – besides the concurrence of more sources of vibrations – frequency profile may transitorily depend from the "side" (front/back or left/right) of origination of the sound: this may point at the differential activation of anterior vs. posterior or left vs. right wing muscle groups.

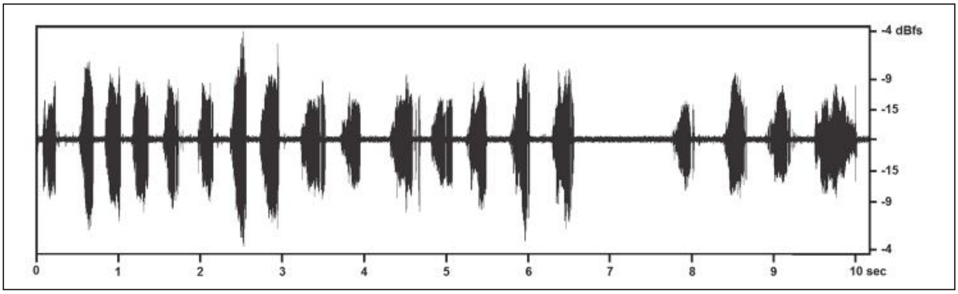

Fig. 14 - Sound pressure envelope of a 250 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019.

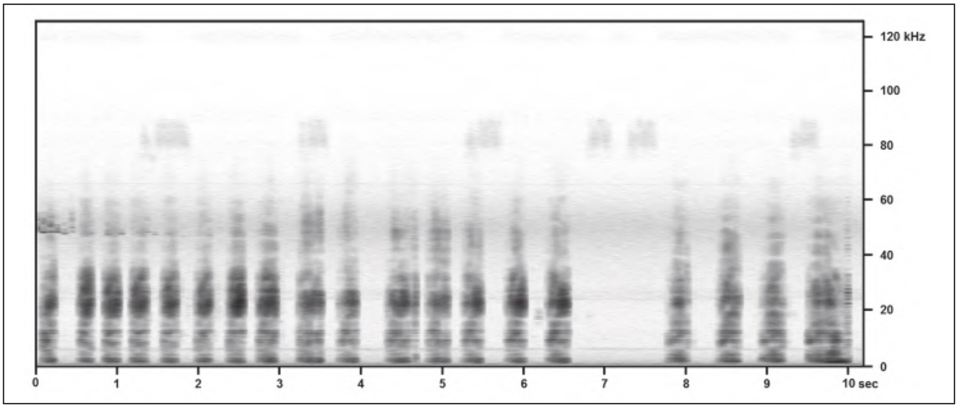

Fig. 15 - Time/frequency spectrogram of a 250 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019.

Discussion

Considering that this report is strictly related with the activity of burrowing by a Sphecid wasp, we decided to provide a short summary about this behaviour in some Hymenopteran families, and an equally compendious digest about the biology of *Sphex*.

Digging behavior in sphecoidea

As reported by Krombein (1984), burrow digging wasps in the families Pompilidae, Sphecidae and Vespidae were divided by Olberg (1959) in four categories based on their excavation behaviour, in other words by the way in which anatomical

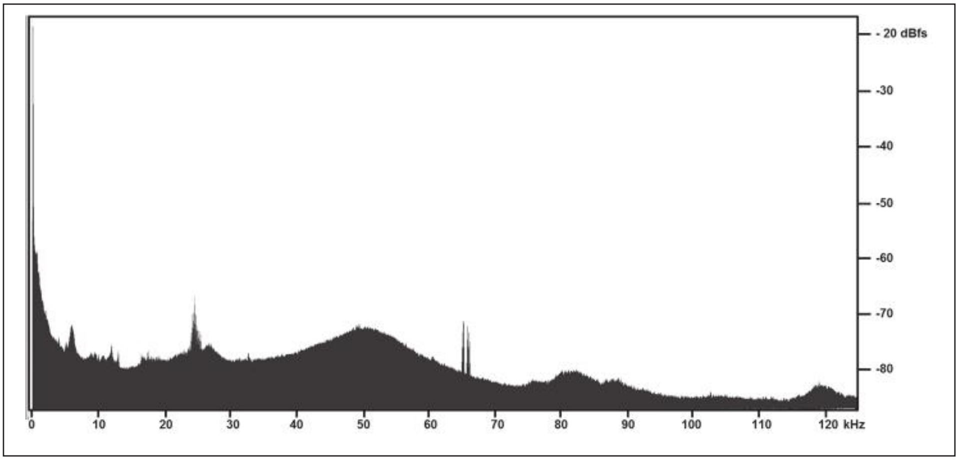

Fig. 16 - Frequency/volume analysis of a 250 kHz recording of the background noise at the recording station, Gutturu Mandara, 24.VIII.2019. Anthropogenic / technogenic noise can be observed as narrow spikes between 65 and 66 kHz. The low, wide bulge centred at around 83 kHz is most probably due to bat sounds, while low frequency peaks are caused by the wind and traffic noise from a near road. The 250 kHz recording is unfiltered.

structures such as foretarsal rakes, hind tibiae, head, mandibles, pygidial plate are used during the burrowing activities: the four categories include rakers, pushers, pullers and carriers. The excavation behaviour may also be adopted by species, such as *Lyroda subita*, that usually reuse pre-existing burrows (Kurczewski 1991).

According to O'Neill (2001) as well as to Hansell (2005), Sphecidae may adopt all those approaches, depending on the species, even though many species may use different techniques when required (see e.g. the complex behaviours reported by Kurczewski (1968) for *Plenoculus davisi*): they may scrape the soil beneath the body with synchronous strokes of the front legs, with the possible initial use of mandibles (as in *Hoplisoides nebulosus*) to break the ground surface. As examples, *Tachetes* may use the forelegs or even all legs to push the soil, while *Philantus* is reported to both back out from the burrow's entrance pulling lumps of soil between the head and the forelegs, and bulldoze material forward with his head.

Biology of sphex

The Hymenopterans of the genus *Sphex* usually nest in the ground in groups of 50 individuals or more (Janvier 1926; Bohart & Menke 1963). The colonies nest for several years in the same locality and Fernald (1945) reported the record of one *Sphex ichneumoneus* which nested in the same locality for 25 years in a row. Numerous Authors have dealt with the biology of these Hymenoptera including:

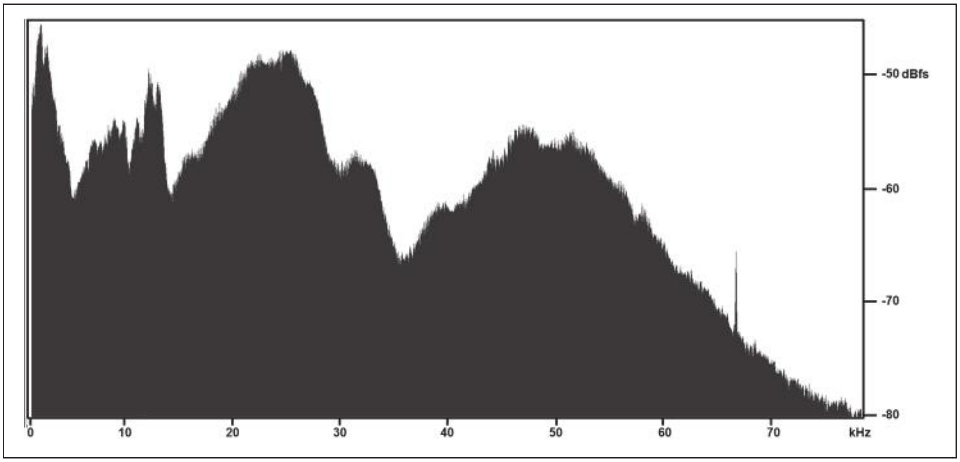

Fig. 17 - First frequency/volume analysis of a 250 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019.

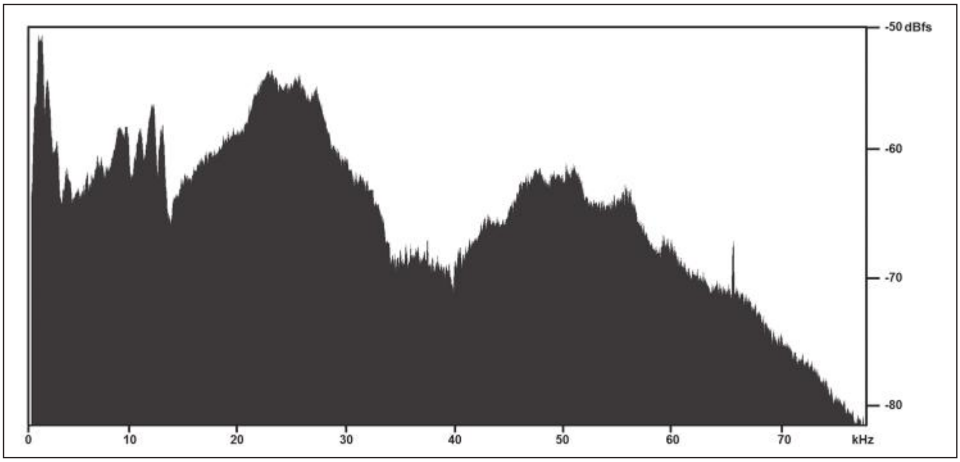

Fig. 18 - Second frequency/volume analysis of a 250 kHz audio sample by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019.

Fabre (1856); Tsuneki (1963); Olberg (1966). The latter summarized several previous works.

Some species, including the two Sardinian candidates *S. funerarius* and *S. flavipennis*, nest in rather open areas with low vegetation while others search for sheltered areas or the interstices of stone floors located outside abandoned buildings or in garden walkways. Typically, the nests are multicellular and varying in depth from 3 to 75 cm depending on the species and type of soil. Each cell is located at the end of a side branch of the main gallery. There are species such as *S. lucae* Saussure and *S. subtruncatus* Dahlbom that nest using a gallery for each pedotrophic nest. However, the latter species digs numerous galleries close to the main one. There are also species that close the tunnel entrance when they go hunting, while others leave the entrance open. The preys are mainly made up of several species of Tettigoniidae but occasionally they are also supplied Gryllacrididae and Gryllidae.

Each female tends to supply the pedotrophic nest with prey belonging to a single species, probably as a consequence of its frequency near the nest. The preys are transported to the nest with the back upwards; when they are too big and heavy they are dragged on foot or fluttering. Cazier & Monterson (1965) observed that in one case *S. lucae* amputated at the base the antennae of the grasshopper which it carried to the nest. The eggs are deposited on the mesosomatic sterna of the first prey. Prey supply is usually massive, but *S. subtruncatus* supplies the nest progressively. *Sphex argentatus* has an interesting habit of digging accessory tunnels, normally two, one on each side of the main gallery; they are excavated when the main gallery is completed and the entrance has been temporarily closed. Tsuneki (1963) asserts that these accessory galleries, left open, are intended to divert the attention of parasites.

The parasites of *Sphex* belong to the Sarcophagidae and Tachinidae but it is also known that some ants raid Sphecidae nests.

Sound generation associated with burrow digging

Sphecid wasps compact and consolidate the walls of the burrow by pressing their head against the substrate, with or without the interposition of tools, and by activating wing muscles, a behavior aimed at ensuring the safety and the solidity of the burrow walls. The vibrations generated during this behaviour manifest as a typical buzzing sound, the "loud humming noise produced by sphecoid wasps at work" reported by many Authors including Strandtmann (1953): the combination of head thrust and buzzing is often reported in literature, e.g. in the detailed descriptions by Brockmann (1984), who also describes the usage by several species of *Ammophila* of tools including stones, leaves, twigs or small clumps of soil held between the mandibles or simply pushed with the head, then pressed and vibrated against the ground; the same behaviours are also reported by Krombein (1984), who cites the loud buzzing that accompanies both the head pressing action and the biting out of pieces of soil as well as digging in general, with reference to *Sphex sericeus fabricii* Dahlbom, *Ammophila atripes* Smith and several other Ceylonese species. Several other Authors including Ribeiro & Garófalo (2010) describe the buzzing sound associated with activities such as the smoothing of the surface of the cell walls.

Main harmonic elements observed				
Sampling freq.	**96 kHz**		**250 kHz**	
Band number	**Acoustic pressure dBfs**	**Peak frequency Hz**	**Acoustic pressure dBfs**	**Peak frequency Hz**
Three peaks	-45	1000		
Three peaks	-45	1900	-50	1900
Three peaks	-45	2300	-54	2300
Band 1			-61	4000
Band 2	-60	6000	-61	6000
Band 3			-60	7000
Band 4	-63	9000	-58,5	9000
Band 5			-58,5	11000
Band 6			-56	12000
Band 7	-69	12500		
Band 8			-58,5	13000
Band 9	-69	15000		
Band 10	-72	18500		
Band 11			-53	23000
Band 12	-78	24000		
Band 13			-53	25000
Band 14			-52	27000
Band 15			-57	31000
Band 16			-61	47000
Band 17			-61	49000
Band 18			-61	51000
Band 19			-62	55000
Band 20			-66	59000
Note: only the most relevant secondary peaks are considered in this table.				

Tab. 2 - Numeric data from the frequency analyses of 96 kHz and 250 kHz recordings of the buzzing sounds by *cf. Sphex funerarius*, Gutturu Mandara, 24.VIII.2019, ~21:00 CET.

Tentative determination

The distribution of Sphecidae in the Italian territory is well-covered in Pagliano & Negrisolo (2005). Two similar species, *S. flavipennis* (Fabricius, 1793) and *Sphex funerarius* (Gussakovskij, 1934) are reported from the area of Sardinia where the recordings took place (See Negrisolo & Pagliano 1993). According to the original description by Fabricius (1793) *Sphex flavipennis* is distinguished as follows:

– *S. flavipennis: Sphex atra, fronte aurea, abdomine rufo. Habitat in Italia* [...] *Statura et magnitudo S. argentatae. Caput atro, fronte tomento aureo. Thorax laeviusculus puncto calloso, rufo ante alas. Alae flavescentes, apice obscurae. Abdomen petiolatum petiolo apiceque atris. Pedes nigri, antices tibiis ferrugineis*.

The red legs with only the most proximal part of femora darkened, that can be made out in Fig. 6, make the female of *Sphex funerarius* (Gussakovskij, 1934) a more probable candidate.

Conclusions

From visual and bioacoustic observation, it can be concluded that the specimen observed was engaged in exactly the kind of digging and consolidation activity well-documented for its genus and family.

Considering that the tip of the abdomen was clearly and constantly visible vibrating at the entrance of the burrow, it's most probable that the insect was in the initial phase of the its digging / consolidation activity – and this may be confirmed by the fact that it never completely concealed itself by entering the burrow, and that it promptly exited the tunnel as soon as it was disturbed by the first flashes from the camera. Although suboptimal, the pictures of the head, covered in dirt, confirm that heads and mandibles were pressed against the soil.

Even though unaccompanied by specimen capture and extended observations, this short report elucidates how the buzzing sounds associated with the soil-compacting head thrusts aided by the activation of wing muscles in Sphecidae, generate also ultrasounds in a peculiar pattern. Being the first report of this kind, it's currently impossible to ascertain whether those sounds can be considered as species-specific as sexual calls in other insect groups.

In stereo recordings taken from 10-15 cm distance, two phenomena are apparent during the buzzing/vibrating action associated with digging:

– the decoupling of two contralateral or antero-posterior sets of wing muscles - by the blatant decoupling of right and left channel in frequency analyses;
– the concurrence of no less than two vibration sources in each set - by the appearance of two concurrent, phase-shifted pulse trains in the sound pressure envelopes.

The authors hope that this paper, born by serendipity, may promote further, more organized comparative field studies.

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