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## First data on Cicadas of Kefalonia, Greece (Hemiptera: Cicadidae), including bioacoustics

### Первые сведения о цикадах (Hemiptera: Cicadidae) острова Кефалония, включая биоакустику

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KEY WORDS: Hemiptera, Cicadidae, singing cicadas, fauna, bioacoustics, Kefalonia Island, Greece.

КЛЮЧЕВЫЕ СЛОВА: Hemiptera, Cicadidae, сигналы, биоакустика, фауна, остров Кефалиния, Греция.

**ABSTRACT.** No cicada records for the Greek Ionian island of Kefalonia existed so far. The fauna of singing cicadas (Hemiptera: Cicadidae) of Kefalonia island (Cephalonia) has been investigated on the field excursions in 2010, 2016 and 2018 with classic and bioacoustic methods, using recording equipment for sonic range and ultrasonic detectors. We discovered 5 species: *Lyristes plebejus* (Scopoli, 1763), *Cicada orni* Linnaeus, 1758, *Cicadatra atra* (Olivier, 1790), *Dimissalna dimissa* (Hagen, 1856), and *Tettigettula pygmaea* (Olivier, 1790).

**РЕЗЮМЕ.** До сих пор не было сведений о цикадах острова Кефалония (Ионическое море, Греция). Во время полевых работ в 2010, 2016 и 2018 гг. изучена фауна певчих цикад (Hemiptera: Cicadidae) острова Кефалония (Cephalonia) с помощью классических методов и методов биоакустики, с использованием записывающего оборудования для звукового и ультразвукового диапазона. Обнаружено 5 видов: *Lyristes plebejus* (Scopoli, 1763), *Cicada orni* Linnaeus, 1758, *Cicadatra atra* (Olivier, 1790), *Dimissalna dimissa* (Hagen, 1856) и *Tettigettula pygmaea* (Olivier, 1790).

### Introduction

Greece is in a key position in the Mediterranean, one of Earth's biodiversity hotspot [see Myers et al., 2000]. Also singing cicadas (Hemiptera: Cicadidae) are well represented in Greece [Jach, 2013] but, despite their large size and strong acoustic impact, in recent years only several studies have been conducted on these insects in the country, dealing mainly with bioacoustics and providing the description of several new species [e.g. Gogala et al., 2008, 2009, 2011, 2012, 2013, 2017; Gogala, Drosopoulos, 2006; Gogala, Trilar, 2014; Quartau, Simões, 2005; Simões et al., 2000, 2006, 2013; Simões, Quartau, 2008, 2013; Trilar, Gogala, 2010].

However, there are no cicada studies focused on Ionian Islands and, to date, no data have been published for Kefalonia island (Cephalonia, Kefallinia or Kephallenia, Greek: Κεφαλονιά or Κεφαλλονιά) [see Gogala et al., 2017], which is the largest of the Ionian Islands in western Greece and the 6<sup>th</sup> largest island in Greece [see Cianferoni, 2019].

The present work lists the first records of cicadas for Kefalonia.

## Material and methods

In the years 2010, 2016 and 2018 we investigated the singing cicadas of Kefalonia Island. In the periods from July 13. to 15., 2010 and in August 5. to 14., 2016 we (TT and MG) conducted the field work with the use of classical and bioacoustic methods. Additional field work was done (FG, FC and FC) in the period July, 22. to 25., 2018 (Fig. 1).

For the sound recordings we used microphones sensitive in sonic range (Telinga Pro 6 stereo, parabola diameter 57 cm) and in ultrasonic range (ultrasonic detector Pettersson D-200 with microphone mounted in front of a Telinga reflector (57 cm diameter) or smaller metal reflector (15 cm diameter)) in combination with Solid State recorders Marantz PMD660 and Zoom H2. For sound analyses we used Raven 1.5 (Cornell Lab of Ornithology), Amadeus Pro 1.3 (HairerSoft), Wave Pad (NHC Software) and Seewave package [Sueur et al., 2008] as a part of R statistic software. Using these methods we were able to get much more representative data about the presence and distribution of singing cicadas.

We first localized cicadas acoustically, recorded and then collected them with an entomological net if possible. Morphological investigations were made on dry prepared specimens. Higher classification and morphological terminology are after Moulds [2005].

The specimens collected in the field work are preserved in the collection of the Slovenian Museum of Natural History in Ljubljana, Slovenia, and in the private collections of some of the authors: Filippo Ceccolini in Rassina (Arezzo), Italy, Fabio Cianferoni and Francesca Graziani in Florence, Italy. All the sound recordings are stored in the Wildlife Sound Archive of

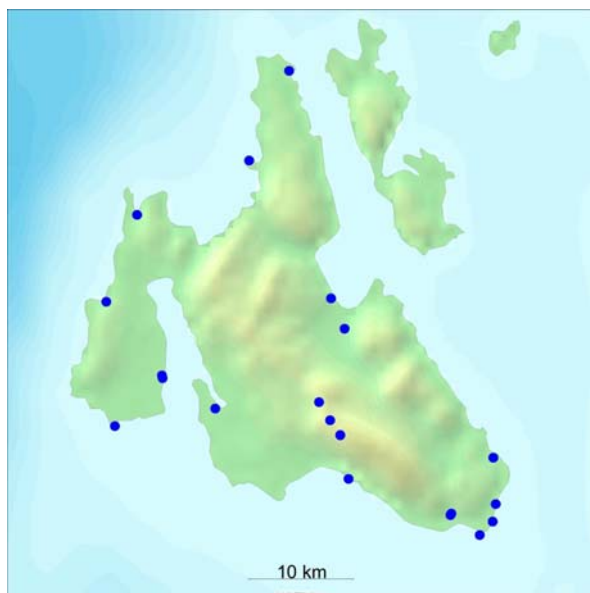


Fig. 1. Localities investigated during our field excursions to Kefalonia 2010, 2016 and 2018.

Рис. 1. Места сбора материала на о.Кефалония в 2010, 2016 и 2018 гг.

Slovenian Museum of Natural History in Ljubljana. Selected sound samples are available also on the web pages *Songs of the European singing cicadas*: <<http://www.cicadasong.eu/>>.

For each locality, the following information is given: locality name, coordinates, elevation (a.s.l.), date, type of data (song recorded, song heard, photographed or collected), number of specimens if collected, repository or source and collectors of the data. Geographical coordinates are in decimal degrees (datum WGS84). Number of decimals varies according to the accuracy of the data. The uncertainty (in metres) of the data was indicated according to the point-radius method [Wieczorek et al., 2004].

Distribution maps were created with GPS Visualizer [Schneider, 2003–2016], spectrogram and oscillogram with Seewave package [Sueur et al., 2008] as a part of R statistic software.

Abbreviations used in material examined:  
 PMSL = Slovenian Museum of Natural History, Ljubljana, Slovenia  
 CFCC = F. Ceccolini collection, Rassina (Arezzo), Italy  
 CFCF = F. Cianferoni collection, Florence, Italy  
 CFGR = F. Graziani collection, Florence, Italy  
 un. = uncertainty

## Species account

### Subfamily Cicadinae

#### *Lyristes plebejus* (Scopoli, 1763)

Figs 2–3.

MATERIAL EXAMINED. Assos, Assos Fortress, 38.382833° N 20.533983° E (un. = 10 m), 142 m, 8.VIII.2016, song heard, photographed, T. Trilar, K. Prosenč Trilar; Lixouri, 38.198567° N 20.438733° E (un. = 10 m), 5 m, 9.VIII.2016, song heard, T. Trilar, K. Prosenč Trilar; Petani, 38.2612° N 20.3780° E (un. = 5 m), 10 m, 25.VII.2018, photographed, F. Graziani.

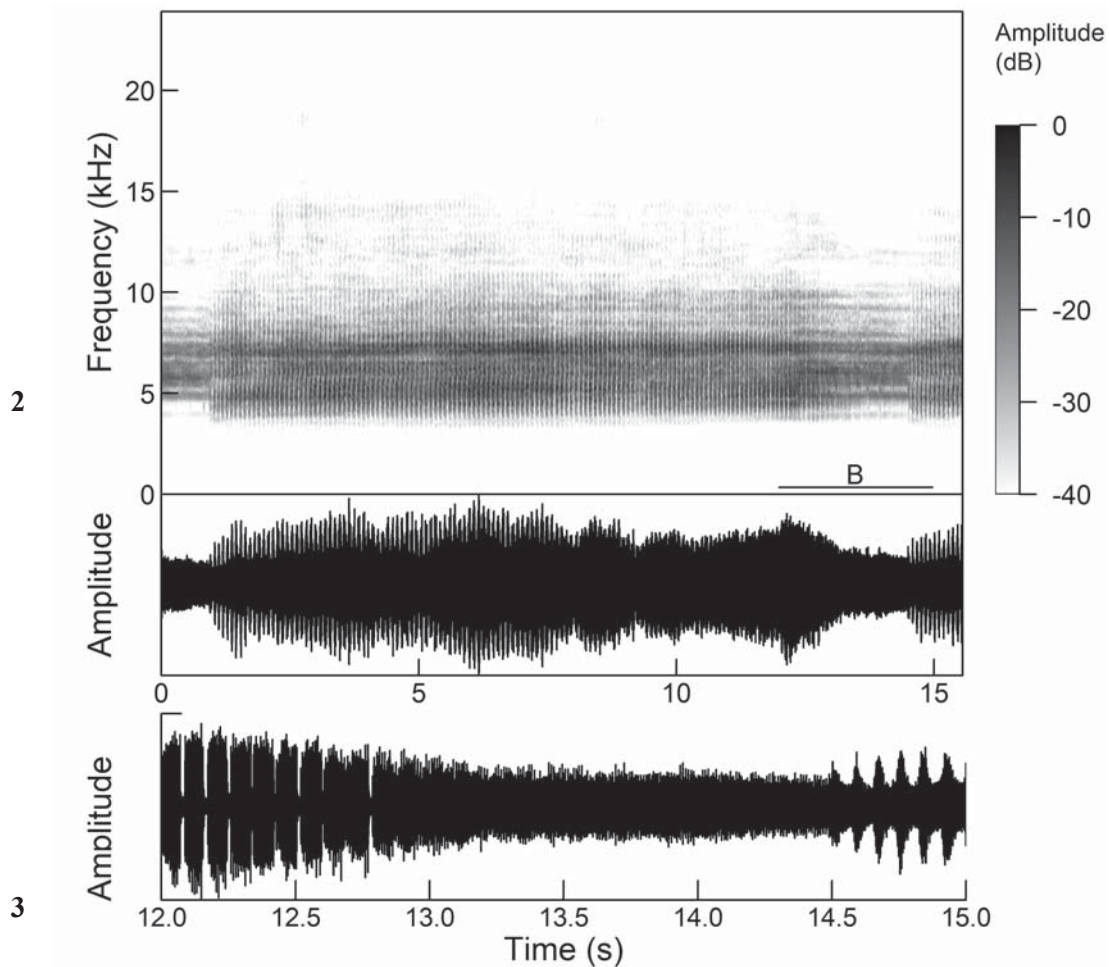
GENERAL DISTRIBUTION. It occurs in the southwestern part of Europe, in Portugal and Spain and extends its distribution range to northern and eastern Mediterranean [Nast, 1972; Boulard, 1995a, b; Gogala, 1998, 2002]; *L. plebejus* was recorded also for SE Azerbaijan [Tishechkin, 2003] but Simões and Quartau [2013] and Gogala and Trilar [2014] stated that from east Aegean *L. plebejus* is replaced by the related *L. gemellus* Boulard, 1988. Further research it is therefore necessary to shed light on the exact distribution of these two species (cf. also with the range of *L. plebejus* provided by Kudryashova [1979]).

REMARKS. The species occurs mainly in closed high shrubland and woodland on different plants, like olive trees, pine trees, oaks, as well as on fruit trees [Sueur et al., 2004; Drosopoulos et al., 2005; Simões et al., 2013].

#### *Cicada orni* Linnaeus, 1758

Figs 4–7.

MATERIAL EXAMINED. Agia Paraskevi bay, 38.26408° N 20.62328° E (un. = 10 m), 10 m, 15.VII.2010, song heard, M. Gogala, T. Trilar, K. Šporar, S. Drosopoulos; Ainos Mt., 38.14711° N 20.63342° E (un. = 10 m), 1320 m, 14.VII.2010, song recorded, M. Gogala, T. Trilar, K. Šporar, S. Drosopoulos; Argostoli, 38.17008° N 20.49685° E (un. = 50 m), 4 m, 25.VII.2018, song heard, F. Ceccolini, F. Cianferoni, F. Graziani; Assos, Assos Fortress, 38.382833° N 20.533983° E (un. = 10 m), 142 m, 8.VIII.2016, song



Figs 2–3. *Lyristes plebejus*: 2 — spectrogram of the calling song, showing one phrase; 3 — oscillogram of the enlarged section B of the calling song, showing the end of one phrase and the beginning of another.

Рис. 2–3. *Lyristes plebejus*: 2 — сонограмма призывного сигнала, показана одна фраза; 3 — осциллограмма части призывного сигнала (увеличенный сектор В сонограммы), показывающая конец одной фразы и начало следующей.

heard, T. Trilar, K. Prosenc Trilar; Atheros, Atheros beach, 38.33588° N 20.41174° E (un. = 10 m), 5 m, 11.VIII.2016, song heard, T. Trilar, K. Prosenc Trilar; Cape Akrotiri, 38.14928° N 20.38751° E (un. = 10 m), 3 m, 9.VIII.2016, song heard, T. Trilar, K. Prosenc Trilar; Fiskardo, 38.459933° N 20.577417° E (un. = 10 m), 11 m, 8.VIII.2016, song heard, T. Trilar, K. Prosenc Trilar; Kateleios, 38.07968° N 20.75436° E (un. = 20 m), 40 m, 22.VII.2018, photographed, F. Graziani; Lixouri, 38.196067° N 20.439433° E (un. = 10 m), 2 m, 14.VIII.2016, collected 1 male 1 female 1 exuvia (PMSL), T. Trilar, K. Prosenc Trilar; Lixouri, 38.198567° N 20.438733° E (un. = 10 m), 5 m, 9.VIII.2016, song heard, T. Trilar, K. Prosenc Trilar; Lourdata, Lourdas beach, 38.10949° N 20.64232° E (un. = 10 m), 4 m, 13.VIII.2016, song heard, T. Trilar, K. Prosenc Trilar; Ainos Mt., 38.12649° N 20.69705° E (un. = 10 m), 1266 m, 6.VIII.2016, song heard, T. Trilar, K. Prosenc Trilar; Ainos Mt., 38.15980° N 20.62222° E (un. = 10 m), 1039 m, 6.VIII.2016, song heard, T. Trilar, K. Prosenc Trilar; Petani, 38.26120° N 20.37800° E (un. = 5 m), 10 m, 25.VII.2018, song heard, F. Ceccolini, F. Cianferoni, F. Graziani; Rhoudi Mt., 38.17538° N 20.61023° E (un. = 10 m), 1021 m, 14.VII.2010, song heard, M. Gogala, T. Trilar, K. Šporar, S. Drosopoulos; Sami, 38.23871° N 20.63811° E (un. = 10 m), 19 m, 13.VII.2010, collected 1 female (PMSL), M. Gogala, T. Trilar, K. Šporar, S. Drosopoulos; Skala, 38.07278° N 20.79949° E (un. = 10 m), 12 m, 7.VIII.2016, song heard, T. Trilar, K. Prosenc Trilar; Skala, c/o Kako (or Kato) Beach, 38.0878° N 20.8029° E (un. = 10 m), 5 m, 24.VII.2018, song heard, F. Ceccolini, F. Cianferoni, F. Graziani; Skala, near Kako (or Kato) Lagadi, 38.12766° N

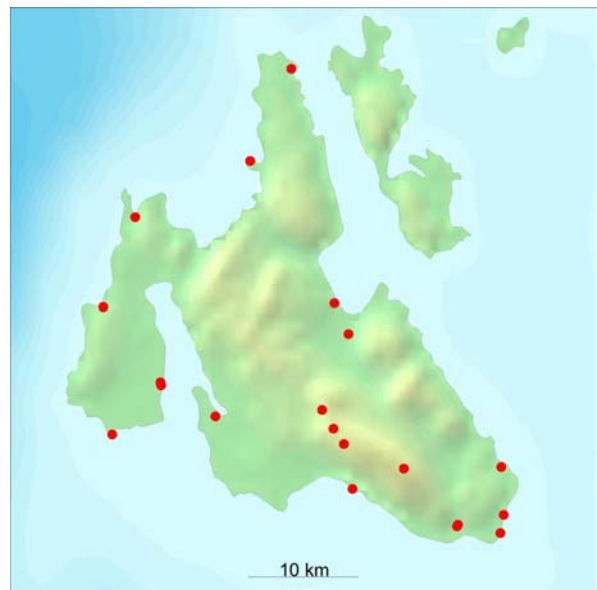


Fig. 4. Map with localities of *Cicada orni* on Kefalonia.  
Рис. 4. Места находок *Cicada orni* на о.Кефалония.

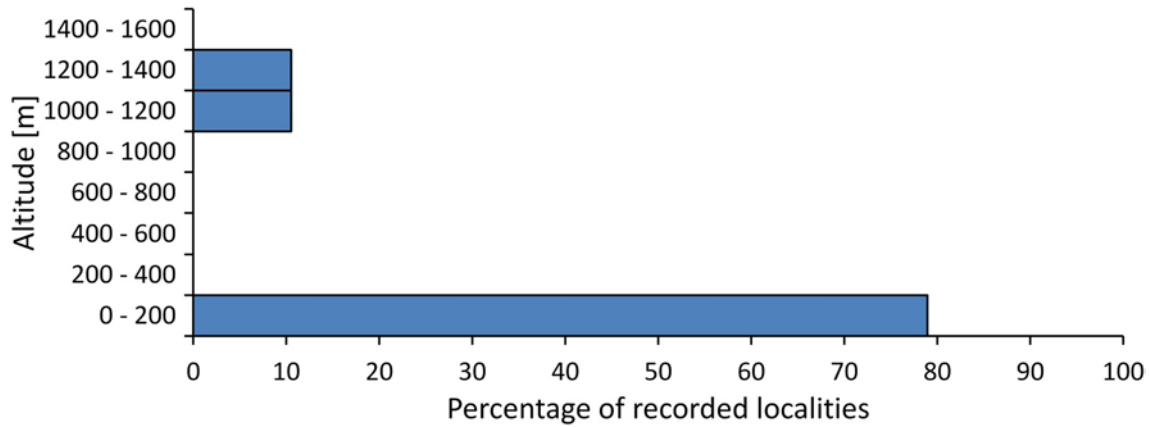
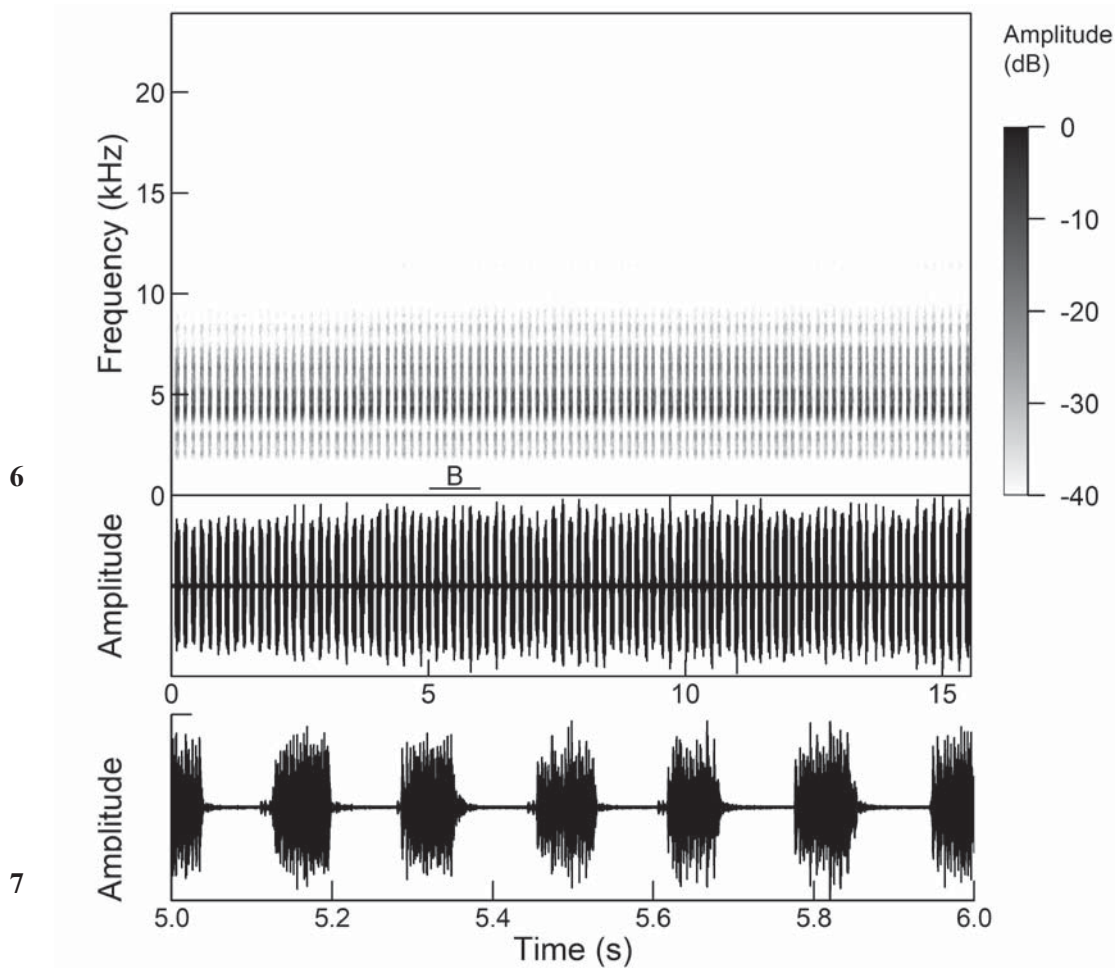


Fig. 5. Vertical distribution of *Cicada orni* on Kefalonia island per 200 m altitudinal belt.

Fig. 5. Распределение *Cicada orni* по высотным поясам (200 м) на о.Кефалония.



Figs 6–7. *Cicada orni*: 6 — spectrogram of the calling song; 7 — oscillogram of the enlarged part (section B of the figure 6) of the calling song.

Рис. 6–7. *Cicada orni*: 6 — сонограмма призывного сигнала; 7 — осциллограмма части (увеличенный сектор В сонограммы на рис. 6) призывного сигнала.

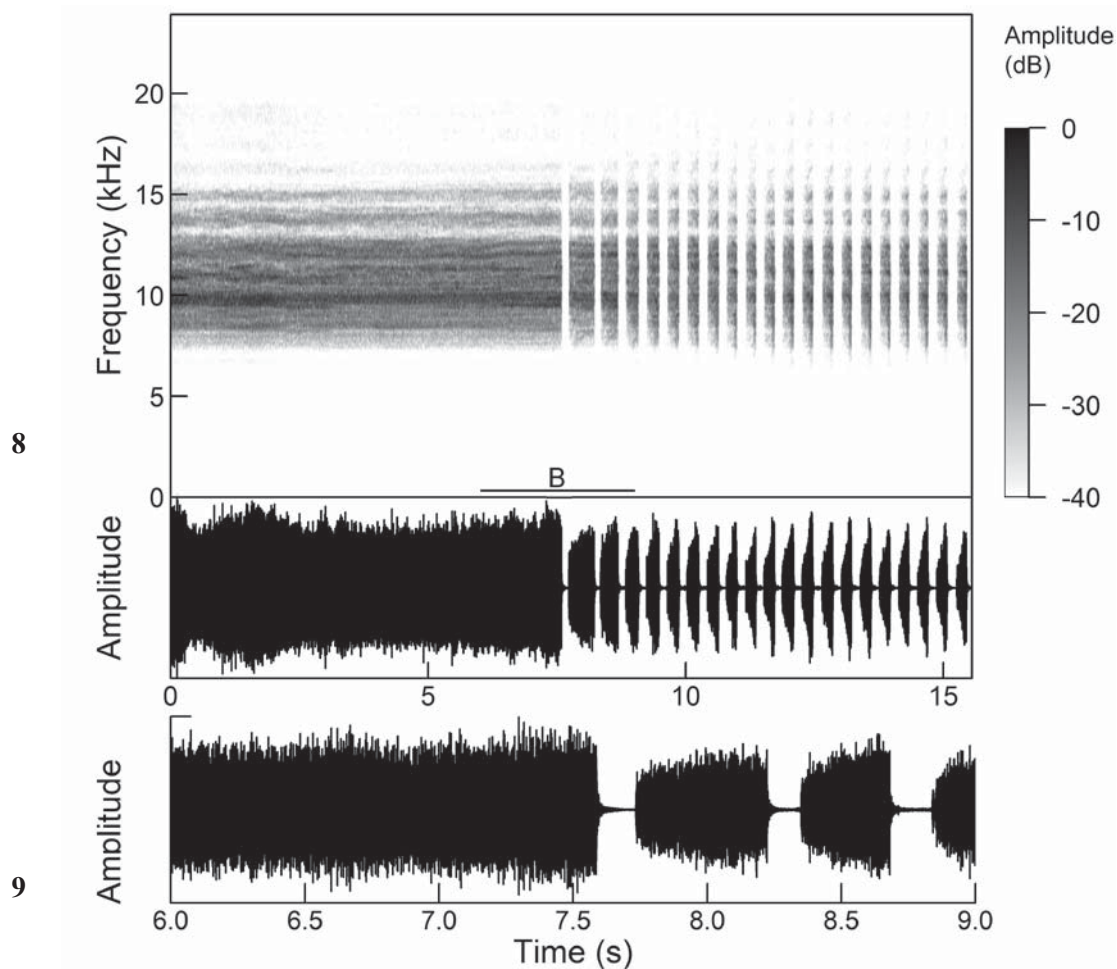
20.80025° E (un. = 5 m), 24 m, 24.VII.2018, collected 4 males (2 CFCC, 1 CFCE, 1 CFGR), F. Ceccolini, F. Cianferoni, F. Graziani.

GENERAL DISTRIBUTION. This is one of the most abundant and common cicada species throughout the Medi-

terranean area [Pinto-Juma et al., 2005], distributed from the Iberian Peninsula to western Greece and Turkey [Quartau et al., 1999], in some countries in the Near East [Nast, 1972], also around the Black Sea [Popov, 1975], North Caucasus

[Tishechkin, 2003], Transcaucasia, Northwestern Iran and the Western Kopet-Dagh Mtn. Range in Turkmenistan [Kudryashova, 1979]. From east Aegean to the East *C. orni* seems to be replaced by the sibling species *C. mordoganensis* Boulard, 1979 [Simões et al., 2000; Gogala, Trilar, 2014].

REMARKS. It occurs in closed high shrubland and woodland on several species of plants (e.g. pine trees, olive trees, oaks, eucalyptus, vineyards) [Patterson et al., 1997; Puissant, Sueur, 2001; Sueur et al., 2004; Pinto-Juma et al., 2005].



Figs 8–9. *Cicadatra atra*: 8 — spectrogram of the calling song, showing transition from continuous song to the part with short echemes; 9 — oscillogram of the enlarged part (section B of the figure 8) of the calling song.

Рис. 8–9. *Cicadatra atra*: 8 — сонограмма призывного сигнала, показан переход от непрерывного звука к серии коротких импульсов; 9 — осциллограмма части (увеличенный сектор В сонограммы) призывного сигнала.

*Cicadatra atra* (Olivier, 1790)  
Figs 8–9.

MATERIAL EXAMINED. Agia Paraskevi bay, 38.26408° N 20.62328° E (un. = 10 m), 10 m, 15.VII.2010, song heard, M. Gogala, T. Trilar, K. Šporar, S. Drosopoulos; Skala, Kaminia beach, 38.06133° N 20.78548° E (un. = 10 m), 20 m, 14.VII.2010, song recorded, M. Gogala, T. Trilar, K. Šporar, S. Drosopoulos; Kateleios, 38.07968° N 20.75436° E (un. = 20 m), 40 m, 22.VII.2018, photographed, F. Graziani.

GENERAL DISTRIBUTION. This species has a turanic-european distribution [Gogala, Gogala, 1999].

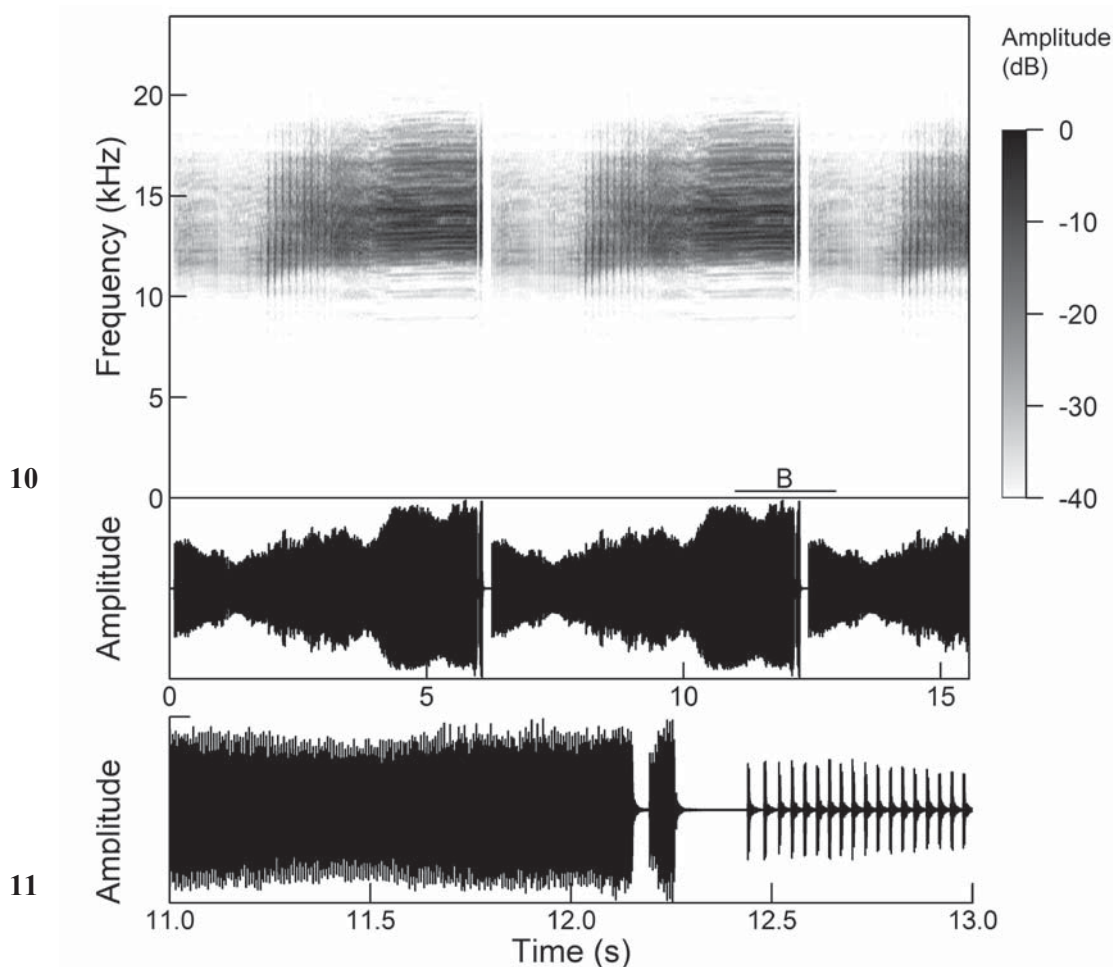
REMARKS. This polyphagous species occurs among various shrubs and low-growing trees [Holzinger et al., 2003].

Subfamily Cicadettinae

*Dimissalna dimissa* (Hagen, 1856)  
Figs 10–11.

MATERIAL EXAMINED. Ainos Mt., 38.14713° N 20.63341° E (un. = 10 m), 1320 m, 14.VII.2010, recorded, M. Gogala, T. Trilar, K. Šporar, S. Drosopoulos.

GENERAL DISTRIBUTION. This species occurs from France, Italy (including Sicily), Balkans, Crete [Gurcel, 2011], and in NE Caucasus [Tishechkin, 2003]. The records from Kazakhstan and Central Asia [Chelpakova, 1996; Mityaev, 1971] are doubtful since they could refer to unidentified Central-Asiatic closely related species [D. Tishechkin, pers. com.].



Figs 10–11. *Dimissalna dimissa*: 10 — spectrogram of the calling song; 11 — oscillogram of the enlarged part (section B of the figure 10) of the calling song, showing the end of one phrase and the beginning of another.

Рис. 10–11. *Dimissalna dimissa*: 10 — сонограмма призывного сигнала; 11 — осциллограмма части (увеличенный сектор В сонограммы) призывного сигнала, показывающая конец одной фразы и начало следующей.

REMARKS. The species occurs high up in the tree canopies [Trilar, Gogala, 2008].

*Tettigettula pygmaea* (Olivier, 1790)  
Figs 12–13.

MATERIAL EXAMINED. Skala, Kaminia beach, 38.06133° N 20.78548° E (un. = 10 m), 20 m, 14.VII.2010, recorded, M. Gogala, T. Trilar, K. Šporar, S. Drosopoulos.

GENERAL DISTRIBUTION. This species is known from Southern Europe, although records from Spain are doubtful [Puissant, Sueur, 2010].

REMARKS. It occurs mainly in xeric sub-humid habitat [Puissant, Sueur, 2010].

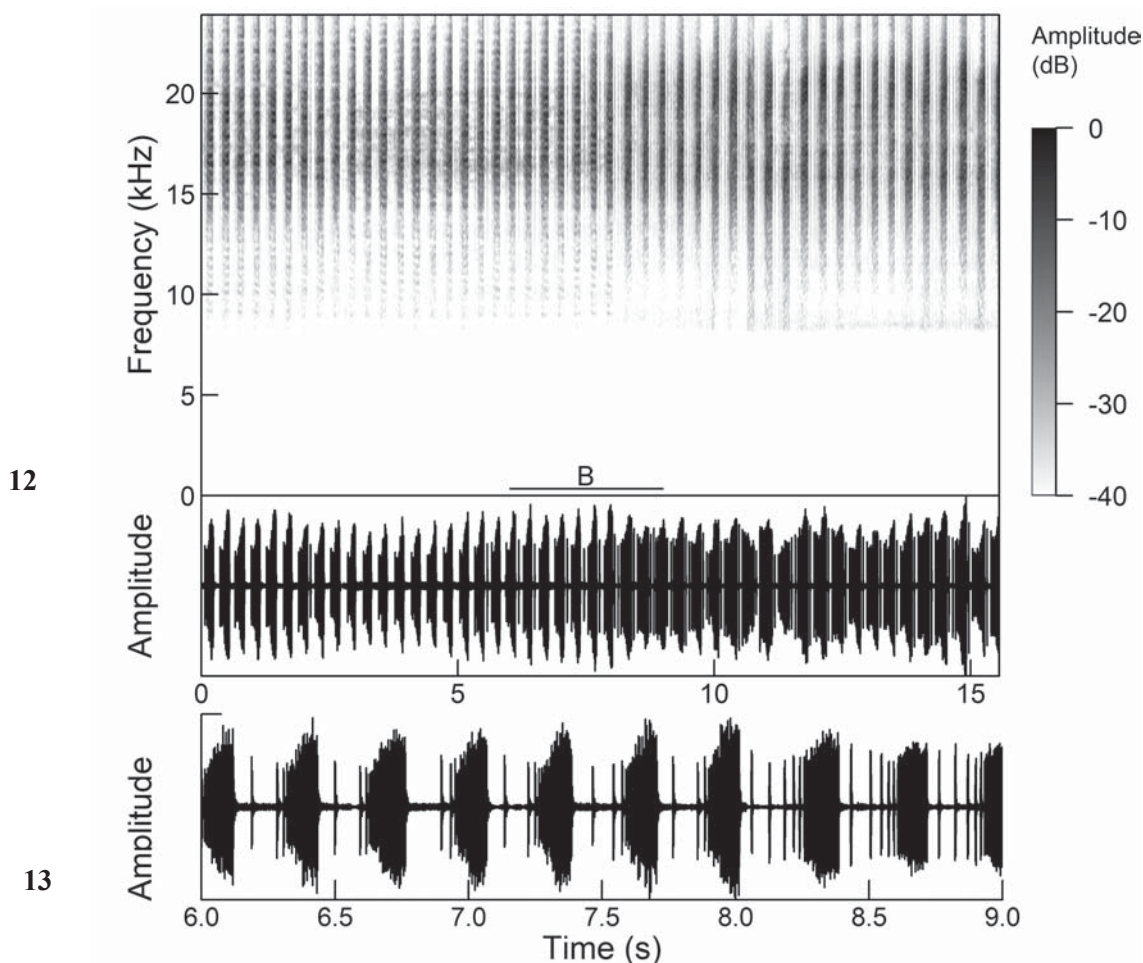
## Discussion

During the field excursions we discovered 5 species on Kefalonia island: *Lyristes plebejus*, *Cicada orni*, *Cicadatra atra*, *Dimissalna dimissa*, and *Tettigettula pygmaea*. Although all the species are common in East Mediterranean and widely distributed also in the Greece mainland, they are recorded here for the first time for Kefalonia, where no records of singing cicadas existed so far.

It is clearly visible from the map of localities visited during our field excursions (2010, 2016 and 2018) in Kefalonia island (Fig. 1), from the distribution map (Fig. 4) and altitudinal distribution chart (Fig. 5) of *Cicada orni* on the island, that Kefalonia is not investigated sufficiently, there is a particular lack of mid-elevation localities (from 100 to 1000 metres) (Fig. 5).

Surprisingly, we did not detect any species of *Cicadetta montana* complex on Kefalonia island, despite very nice and suitable habitat on Ainos Mountain, which is overgrown with an old forest of Greek Fir (*Abies cephalonica* Loudon). The reason can be field work conducted rather late in the cicada season (second half of July and August). There is urgent need to visit the island in the second half of May and in June in order to search for the possible occurrence of species of the *Cicadetta montana* complex.

Moreover, to further improve our knowledge on singing cicadas of Kefalonia, any data from other collections (if exists) should be included and more field work with the use of bioacoustic methods should be done in the future.



Figs 12–13. *Tettigettula pygmea*: 12 — spectrogram of the calling song; 13 — oscillogram of the enlarged part (section B of the figure 12) of the calling song.

Рис. 12–13. *Tettigettula pygmea*: 12 — сонограмма призывного сигнала; 13 — осциллограмма части (увеличенный сектор В сонограммы) призывного сигнала.

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