

DISTRIBUTION OF ENDEMIC CICADAS (HEMIPTERA: CICADIDAE) ON EVIA AND ADJACENT ISLANDS IN GREECE

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Abstract - On the greek island of Evia (Euboea) we found and previously described three endemic species of Cicadettini: *Cicadetta dirfica*, *Cicadetta hannekeae* and *Euboeana castaneivaga*. Only one of them, *C. hannekeae* is present also in continental Greece. We tried to determine their geographical distribution on selected Aegean islands: Evia, Andros, Skopelos, Ikaria and Samos. Only on Andros we discovered one of the Evian endemics, *E. castaneivaga*, on other islands we did not detect any of the Evia endemic species mentioned above. We discuss the possible reasons for such limited distributions and are also providing data about other cicada species found on investigated islands.

KEY WORDS: Hemiptera, Cicadidae, *Cicadetta dirfica*, *Cicadetta hannekeae*, *Euboeana castaneivaga*, geographical distribution

Izveček - RAZŠIRJENOST ENDEMIČNIH VRST ŠKRŽADOV NA EVBEJI IN SOSEDNIH OTOKIH V GRČIJI (HEMIPTERA: CICADIDAE)

Na grškem otoku Evbeji (Evia) smo odkrili in v preteklih letih opisali tri endemične vrste škržadov iz skupine Cicadettini: *Cicadetta dirfica*, *Cicadetta hannekeae* in *Euboeana castaneivaga*. Samo ena od teh vrst (*C. hannekeae*) je prisotna tudi v celinski Grčiji. Ugotavljali smo geografsko razširjenost teh vrst na izbranih egejskih otokih: Evia, Andros, Skopelos, Ikaria in Samos. Samo na otoku Andros smo odkrili eno od teh vrst (*E. castaneivaga*), na nobenem od ostalih otokov nismo našli omenjenih endemičnih vrst. V članku razpravljamo o možnih razlogih za tako omejeno razširjenost teh vrst, obenem pa objavljamo tudi podatke o drugih vrstah škržadov, ki smo jih našli na raziskovanih otokih.

KLJUČNE BESEDE: Hemiptera, Cicadidae, *Cicadetta dirfica*, *Cicadetta hannekeae*, *Euboeana castaneivaga*, geografska razširjenost

Introduction

South-Eastern Europe and particularly Greece is one of the regions with very high biodiversity. This is true also for singing cicadas (Hemiptera: Cicadidae). Cicada species, endemic to Greece, have been described from the continental Greek peninsula (e.g.: *Cicadetta hannekeae* Gogala, Drosopoulos & Trilar 2008, *Cicadivetta goumenissa* Gogala, Drosopoulos & Trilar 2012), from Crete (*Cicada cretensis* Quartau & Simões 2005, *Cicadivetta carayoni* Boulard 1982, *Pagiphora aschei* Kartal 1978), from Mt. Olympus and Mt. Ossa (*Cicadetta olympica* Gogala, Drosopoulos & Trilar 2009, *Cicadetta kissavi* Gogala, Drosopoulos & Trilar 2009) and we should not forget the cicada species present on the eastern Greek islands (*Lyristes gemellus* Boulard 1988, *Cicada mordoganensis* Boulard 1979) with distributions extending to Turkish Anatolia. Recently, also two *Cicadatra* species have been described from Greek islands (*Cicadatra icari* Simões, Sanborn & Quartau 2013 and *Cicadatra karpathoensis* Simões, Sanborn & Quartau 2013). The island Evia (Euboea, Euboia) is known for high endemism of plants (Trigas & Iatrou 2006) but also of cicadas (*Cicadetta dirfica* Gogala, Trilar & Drosopoulos 2011, and *Euboeana castaneivaga* Gogala, Trilar & Drosopoulos 2011).

The very high endemism invited us to investigate in the past few years the distribution of the endemic and other cicadas on the island of Evia and adjacent islands, Skopelos and Andros. In addition we searched for cicadas also on two East Aegean islands, Ikaria and Samos. We expect that present biogeographical data could bring more light to the questions which factors influenced the speciation and distribution of mountain cicadas in this part of the country.

Materials and Methods

We made field trips to Evia during the cicada season many times through several years (central part above Ano Steni 2-4. and 9-10.7.2006, 2.7.2008, 8.7.2010 and 15.6.2012). We visited Mt. Olimbos in Central Evia on 16.6.2012 and Mt. Pixaria above the village Vlahia on 9.7.2011, Mt. Kandilio in northern Evia on 3.7.2008, 9-10.7.2010 and 10.7.2011. Northern Evia we investigated during the time period of 12-14.6.2012 and Mt. Ochi in the South on 5.7.2008. During 2011 we visited the islands of Samos (11-12. and 15.7.2011) and Ikaria (13-15.7.2011). In the year 2013 we searched for cicadas on islands Skopelos (21-23.6.2013) and Andros (25-27.6.2013).

For the names and spelling of localities we follow the local inscriptions and transliterations used in the maps of "Road Editions", Athens, 1996-2006: Nr. 4 (Central Greece), 101 (Andros), 209 (Ikaria), 210 (Samos) and 218 (Skopelos). For details of the Northern Evia we used also maps Anavasi 04.

For acoustic detection and recording of songs we used Telinga Pro 5 stereo microphone with plug-in power and parabola of 57-cm diameter and/or the ultrasonic detector Pettersson D-200 (heterodyne system) with electret microphones of the same producer (frequency range 10–120 kHz), mounted in front of a Telinga reflector (57-

cm diameter) or a Renault R-4 front light metal reflector (Gogala 2013) and connected to the solid state recorders Marantz PMD-660, PMD-670 (sampling rate up to 48 kS) or Zoom H2 (sampling rate up to 96 kS). For sound analyses we used RAVEN 1.4 (Cornell Lab of Ornithology) and AMADEUS Pro 2.0 (HairerSoft). For graphics in this paper (Fig. 4) we used the R software platform (R Development Core Team 2008).

For the nomenclature of Cicadettini we follow the publication of Puissant and Sueur (2010).

The distribution maps were created by GPS Visualizer (Schneider 2003–2013).

Collected specimens are deposited in the collection of the Slovenian Museum of Natural History (PMSL). Song recordings are deposited in the Slovenian Wildlife Sound Archive of the same museum. Samples of selected recordings are available on the web pages *Songs of European singing cicadas* (<http://www.cicadasong.eu>).

Results

Since our descriptions of endemic species from Evia (Gogala et al. 2008, 2011) we tried to gather more distributional data for cicadas on Evia and surrounding Aegean islands to get some ideas about the reasons for the endemism in this region, well known also from botanical studies (e.g. Trigas & Iatrou 2006). We visited again some less investigated parts of Evia, the island Skopelos in the North, the island Andros in the South-East and two East-Aegean islands Ikaria and Samos. Our main aim was to get distributional data of Cicadettini, mainly a complex of endemic mountain cicadas (*Cicadetta montana* s. lato) and a close related species *Euboeana castaneivaga*. But during these studies we heard, recorded and also collected other species of cicadas and these data we also present in this paper as a contribution to cicada fauna of Greece.

Distribution of mountain cicada species endemic to Evia and adjacent islands

***Cicadetta hannekeae*:** This endemic species of Cicadettini inhabits most mountains of continental Greece including Peloponnese (Gogala et al. 2008, 2013). On Evia we detected it just in the northwestern part of the island (NW), on Mt. Kandilio (Gogala et al. 2011), on Mt. Telethron, in Drymona gorge (Kataraktes Drymona) and on nearby Mt. Kavalaris (Fig. 1). As expected from previous investigations (Gogala et al. 2008, 2013) we found this species on localities with elevations of 450 – 1150 m ASL (Fig. 4) The closest localities in continental Greece are on mountains Othris (Gogala et al. 2009), Parnitha, Elikonas (Gogala 2013) and Parnassos (Gogala et al. 2008).

In the central (C) and southeastern (SE) division of Evia (for biogeographic division of Evia compare Gogala et al. 2011 and Trigas & Iatrou 2006) we never detected this species!

***Cicadetta dirfica*:** This endemic species of Evia is restricted to the central part of this island above Ano Steni and below Mt. Dirfis, where it is quite abundant (Gogala



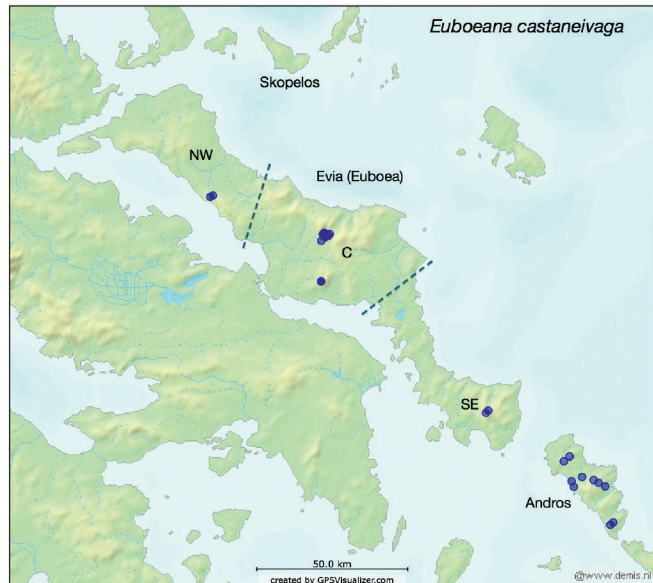
Fig. 1: Map with localities of the Greek endemic species *Cicadetta hannekeae* on Evia and adjacent mainland. Dashed lines show the borders between the three centers of plant endemism on Evia: NW - northwestern, C - central and SE - southeastern (after Trigas and Iatrou 2006). Continental Greece and islands Evia, Skopelos, Andros, Ikaria and Samos were investigated.

et al. 2011). During our expedition in 2011 we found it also on Pixaria mountains (about 800 m ASL) near the northern coast of Evia above the village Vlachia (Fig. 2). According to botanic studies (Rechinger 1961, Trigas & Iatrou 2006) this mountain ridge also belongs to the central region (C) of endemism. During our visit to Evia in 2012 we searched for this species also on Mt. Olimbos, but without success. It is still



Fig. 2: Map with localities of *Cicadetta dirfica*, endemic on Evia. For other explanations see Fig. 1.

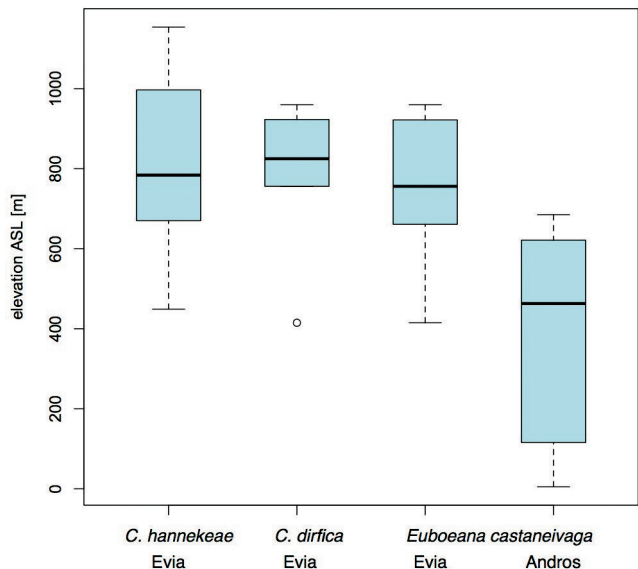
Fig. 3: Map with localities of *Euboeana castaneivaga*, endemic on Evia and Andros. For other explanations see Fig. 1.



possible, that it lives also on this mountain in places of higher elevation, which we did not visit due to logistic problems. We found this species on localities with the elevation of 415 – 960 m ASL (Fig. 4).

***Euboeana castaneivaga*:** This endemic genus and species of Cicadettini, which is closely related to the *Cicadetta montana* complex of species, is present on Evia at

Fig. 4: Boxplot of the vertical distribution of the three endemic species *Cicadetta hannekeae*, *C. dirfica* and *Euboeana castaneivaga* on Evia and Andros. Thick horizontal lines - median values, box hinges - 1st and 3rd quartiles, whiskers - minimal and maximal values, o - one outlier.



elevations between 415 and 960 m (Fig. 4) in many places throughout the whole island with the exception of some mountains in the North of the island (Gogala et al. 2011, Gogala 2013 and new unpublished data). It was first found on the slopes of Mt. Dirfis, above Ano Steni, later in the South-East on Mt. Ochi and also in the northern part of the island on Mt. Kandilio. We detected and recorded it also on Mt. Olimbos but it is apparently absent from mountains Telethron, Kavalaris and Pixaria (Fig. 3).

However, we were surprised by its presence on the island **Andros**, where we found it on many localities in contrast to Evia from the seacoast to the highest mountains (5 - 685 m, Fig. 4).

Negative results: None of these endemic species of Cicadettini we could find on the island of Skopelos and on the East-Aegean islands Ikaria and Samos. We searched for them in places from the seacoast to the highest mountains on these islands but without success.

Other faunistic data for cicadas on the investigated islands

Evia: The biggest island in this region, which Simões et al. (2006) considered as a part of mainland is in fact a region of high endemism for various organisms. In addition to the mentioned endemic cicadas (*C. hannekeae*, *C. dirfica* and *E. castaneivaga*), the island is inhabited also by the following “lowland” cicada species: *C.*

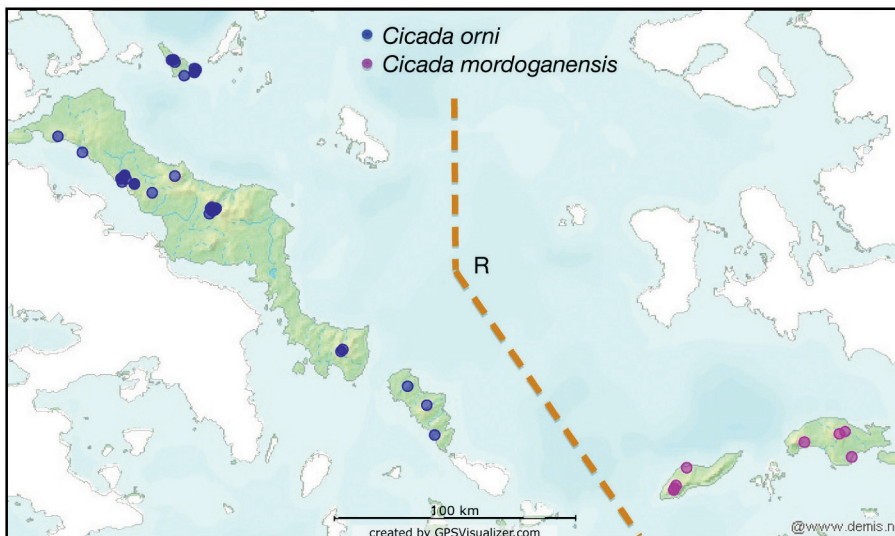


Fig. 5: Map with localities of *Cicada orni* and *C. mordoganensis* on the investigated islands Evia, Skopelos, Andros, Ikaria and Samos. R - Rechinger's line dividing European and Asian biogeographic part of the Aegean sea. Parts of land, not taken into account in this investigation are shown in outline.

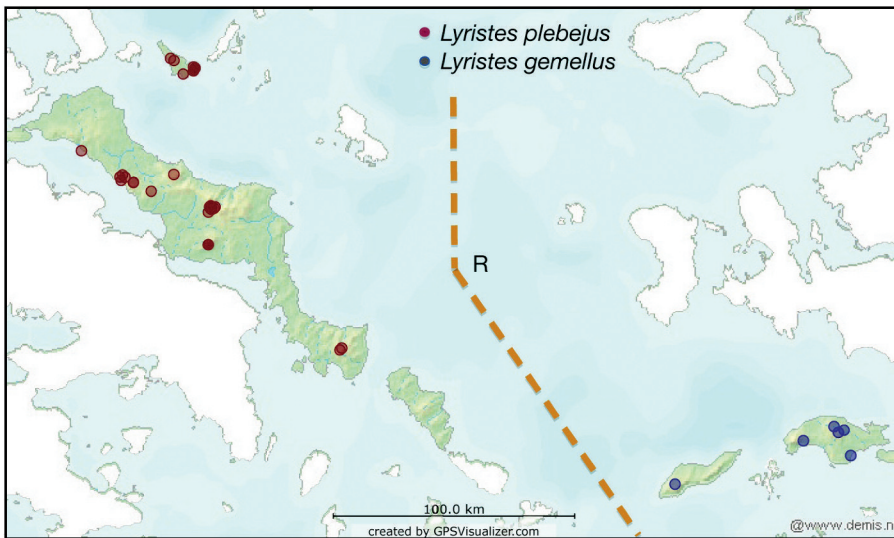


Fig. 6: Map with localities of *Lyristes plebejus* and *L. gemellus* on the investigated islands Evia, Skopelos, Andros, Ikaria and Samos. For other explanations see Fig. 5.

orni, *L. plebejus*, *C. atra*, *T. haematodes*, *D. dimissa*, *Tettigetula pygmaea* (Olivier 1790) and *P. annulata* (Figs. 5-10). For the south-eastern part of the island (SE) we do not have enough distributional data for such common species since we focused our attention just to Mt. Ochi, the highest mountain in this part of the island.

Andros: We mentioned above the abundance of *E. castaneivaga* on this island, which is separated from Evia just by a sea gap of 12 km. It has 5 mountain ridges with highest peaks about 1000 m ASL. We found on Andros only two other species of cicadas, *Cicada orni* Linnaeus 1758 and *Cicadatra atra* (Olivier 1790) (Figs. 5, 7). Previously, *C. orni* has been mentioned from this island in the literature (Simões et al. 2006, 2008). On some other islands (e.g. Skopelos) similar time period was long enough to detect more species of cicadas. However, we searched on Andros for cicadas on 13 localities from mountains to seacoast on the whole island and therefore we believe that our data are representative.

Skopelos: Skopelos island we visited because it has relatively high mountains (Delfi 681 m, Mt. Palouki 567 m) with different geology, the forest is well preserved and it is not far from the northern edge of Evia (about 24 km). We did not discover there neither any species of mountain cicadas nor the related species *E. castaneivaga* which is endemic to Evia and Andros. However, the island has rich populations of other cicada species.

We found there on calcareous Mt. Delfi the following species: *Lyristes plebejus* (Scopoli 1763), *Cicada orni*, *Cicadatra atra*, *Tibicina haematodes* (Scopoli 1763) and *Dimissalna dimissa* (Hagen 1856) (Figs. 5, 7-9). On Mt. Palouki with different

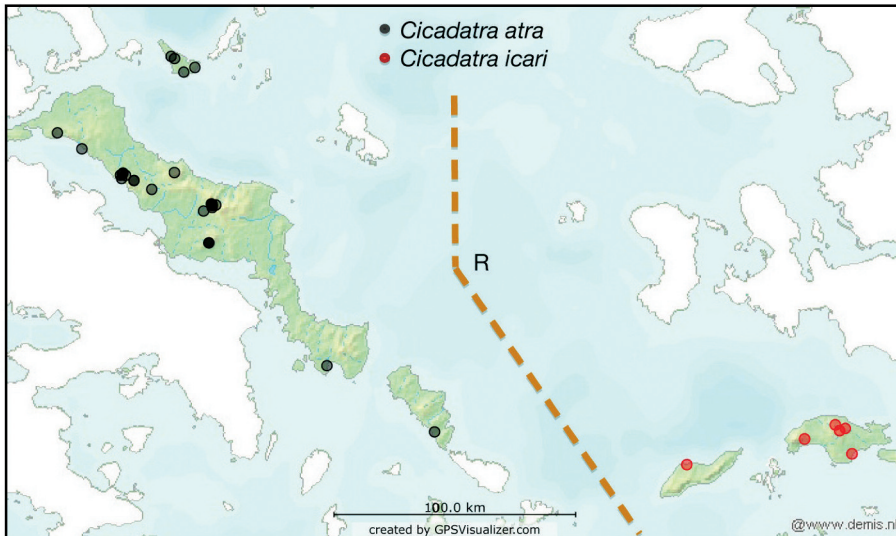


Fig. 7: Map with localities of *Cicadatra atra* and *C. icari* on the investigated islands Evia, Skopelos, Andros, Ikaria and Samos. For other explanations see Fig. 5.

geology and vegetation we detected the same species with exception of *D. dimissa*. Drosopoulos et al. (2006) mention also *Lyristes* from this island and Simões et al. (2008) mention *C. orni*.

Ikaria: The islands Ikaria and Samos were previously investigated by French, Greek and Portuguese colleagues (Drosopoulos et al. 2006, Simões et al. 2000, Quartau & Simões 2006, Simões & Quartau 2008, 2013, Simões et al. 2013), who found their fauna of cicadas typical for Eastern Aegean islands and Anatolia with the recently described *Cicadatra icari* (Simões et al. 2013).

We heard, recorded and also collected there the following species: *Lyristes gemellus* Boulard 1988, *Cicada mordoganensis* Boulard 1979, *Cicadatra icari* and *Tibicina steveni* (Krynicky 1837)(Figs. 5-8). There was no sign of any species of Cicadettini from the sea-coast up to the highest localities with a reasonable vegetation at about 750 m ASL.

Samos: Fauna of cicadas on this island, close to the Anatolian coast, has a similar but longer list of species than Ikaria. We investigated 6 localities with elevations from the seacoast till the places in the mountains over 1000 m ASL.

We heard, recorded and also collected there the following species: *Lyristes gemellus*, *Cicada mordoganensis*, *Cicadatra icari*, *Tibicina steveni*, *Dimissalna dimissa* and *Pagiphora annulata* (Brullé 1832)(Figs. 5-10). The main difference to the island of Ikaria is the presence of two species of Cicadettini: *D. dimissa* and *P. annulata*. Also on this island we did not find any species of the *Cicadetta montana* species complex or the closely related endemic species *E. castaneivaga*.

Localities for all species mentioned above on the islands Evia, Skopelos, Andros, Ikaria and Samos are shown in the Figs. 5-10.

Discussion

There are too many islands in the Aegean sea to make a comprehensive picture of a distribution of endemic mountain cicadas and their related species during a few summer excursions to this region. Therefore we show here just distributional data for the three islands with exception of Fig. 1, where we show also distribution of one endemic species (*C. hannekeae*) at the four localities in the continental Greece. For both endemic species of the island Evia (and Andros) we show all known localities.

From our distributional data in the investigation area we can make the following conclusions. Endemism of singing cicadas in West Aegean islands Evia and Andros is restricted to mountain cicadas and the closely related *Euboeana castaneivaga*.

For other non-endemic Cicadettini we show the distributional data on the investigated islands, Evia, Andros, Skopelos, Ikaria and Samos (Figs. 5-10). A reason for the lack of data for some non-endemic species in the SE part of Evia could be the fact that we visited this part of the island only once for a short time with the focus on Mt. Ochi. However, the islands Skopelos, Andros, Ikaria and Samos were thoroughly investigated in a high season for cicadas, but for a short period of time.

The presence and distribution of endemic cicadas on Evia gave rise to various ideas why this big island close to Greek mainland has such uneven distribution of mountain cicadas: *C. dirfica*, endemic just to Evia and *E. castaneivaga*, endemic to Evia and the closest island Andros. And why *C. hannekeae*, endemic species for most

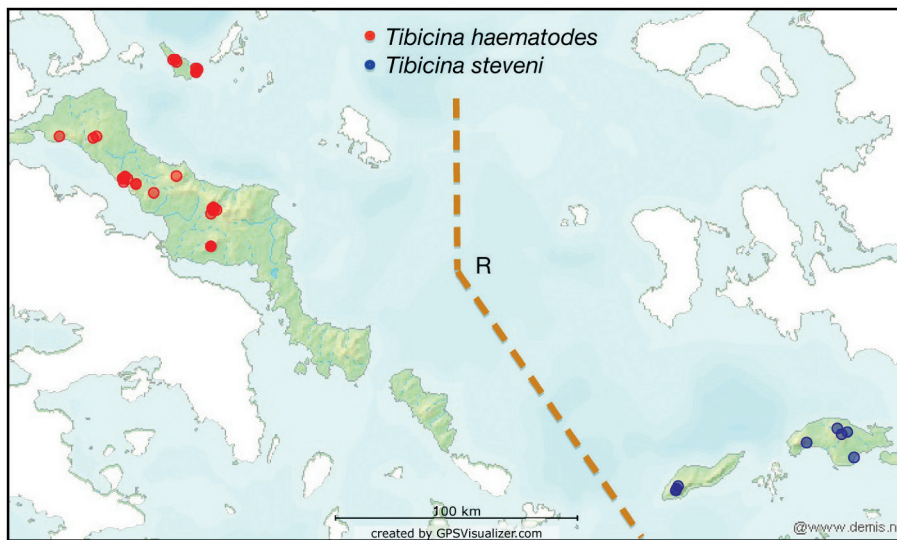


Fig. 8: Map with localities of *Tibicina haematodes* and *T. steveni* on the investigated islands Evia, Skopelos, Andros, Ikaria and Samos. For other explanations see Fig. 5.

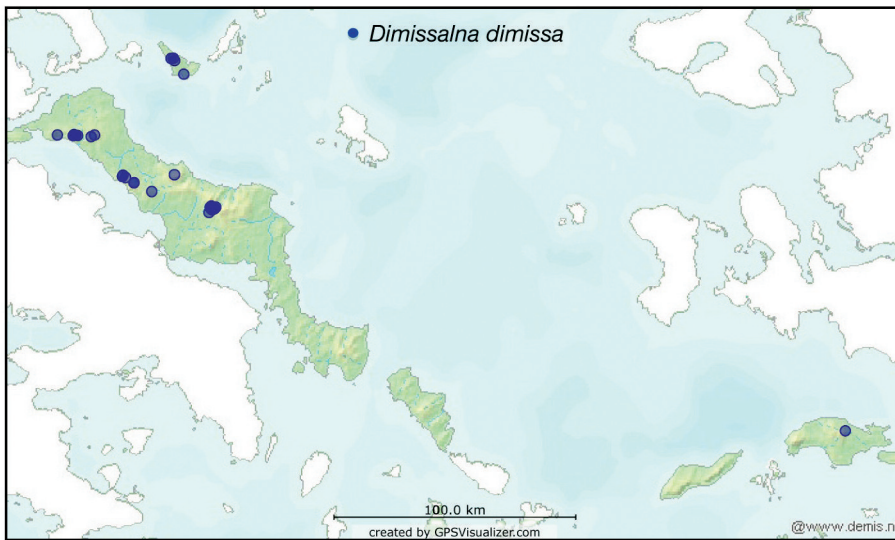


Fig. 9: Map with localities of *Dimissalna dimissa* on the investigated islands Evia, Skopelos, Andros, Ikaria and Samos.

parts of continental Greece below 40° latitude (Gogala et al. 2008), is present just in the northwestern part (NW, Fig. 1) of this island? This species, which can be considered as a Greek endemic element, apparently invaded Evia from the North but could not pass the area of high volcanism along the line between Pili at the northern coast and Kamaritsa in the South near the foothills of Mt. Kandilio. For the same reason the island endemic species *C. dirfica*, which we found only in the central part of Evia (C, Fig. 2) could not invade the northern part of the island and also did not cross the subduction zone in the South-East of the island (SE, Fig. 2). However, the other island endemic cicada *E. castaneivaga* crossed these borders of the three centers of endemism (Trigas & Iatrou 2006), probably due to better flying ability. Nevertheless, this higher mobility was good enough to reach also Andros but for some reasons did not open *E. castaneivaga* the door to the mainland (Fig. 3).

Some ideas about the reason for such endemism and distribution we already expressed in the paper Gogala et al. 2011 after comparison of our data with the botanical investigations done by Rechinger (1961) and Trigas & Iatrou (2006).

The altitudinal distribution of *E. castaneivaga* on Andros is different from the distribution on Evia, where we never detected this species in localities with altitude below 415 m (Fig. 4). On Andros, however, we found it also at the seacoast, what can be explained by the small number of species present on the island. Therefore, we can assume that ecological niches for this small cicada were empty and available. The potential of this species to inhabit also places of low altitude could explain why we found *E. castaneivaga* in all three biogeographic divisions on Evia from Mt. Kandili to Mt. Ochi and on Andros.

Since we never found both endemic species of Evia (*C. dirfica* and *E. castaneivaga*) on the mainland, we discussed the possibility that we could possibly find these or closely related species of cicadas on islands east of Evia where Andros, Tinos, Mikonos, Ikaria and Samos make an island arc with connection to Turkish Anatolia. However, during our investigations of cicadas on Ikaria, Samos and also on coastal parts of Turkey close to Samos (Mt. Samson, Gogala 2013) we did not find any mountain cicadas and no support for such ideas. The only island investigated till now, where we found endemic cicada of Evia was Andros. Again, the best explanation and similarity with a distribution of other organisms we found in botanic endemism. Rechinger (1943, 1950) and Rechinger & Rechinger-Moser (1951) proposed a line in the middle of the Aegean sea, which divides the flora of the West Aegean islands from the flora of eastern islands which contains mainly the Anatolian or Asian floristic elements. This “Rechinger’s line” has been confirmed many times as a biogeographic border between Europe and Asia by newer botanic investigations (Strid 1996). This division is evident also in geographical distribution of most cicada species (Figs. 5-10), with different but closely related species (vicariance!) on both sides of the Rechinger’s line (R).

Therefore we expect to find some locations with endemic cicadas from Evia possibly only on some other islands of Cyclades and on Skyros, which we did not investigate by now.

It seems that geological events of the past, like volcanism and plate tectonics, were most important factors in the speciation and distribution of cicadas in this region

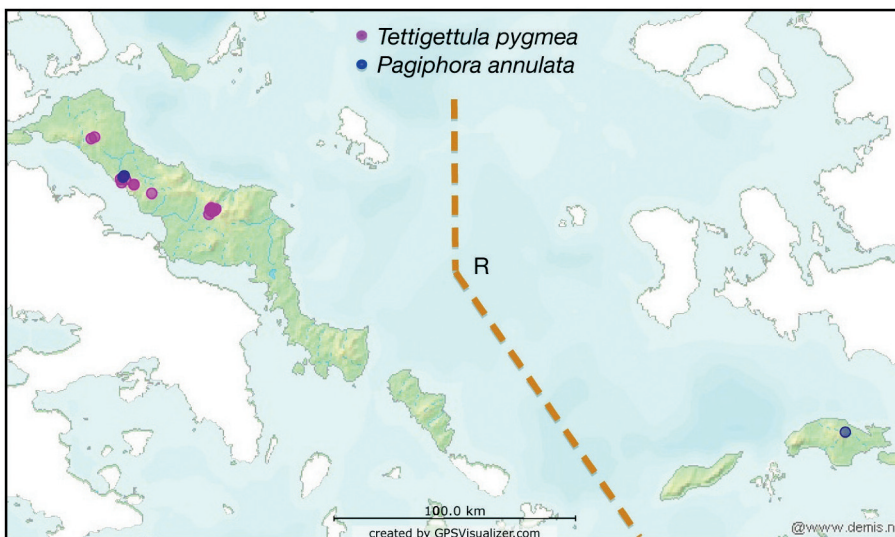


Fig. 10: Map with localities of *Tettigettula pygmea* and *Pagiphora annulata* on the investigated islands Evia, Skopelos, Andros, Ikaria and Samos. According to our knowledge also *T. pygmea* was never found on the Asian side of the Rechinger’s line. For other explanations see Fig. 5.

of Greece. Probably the speciation of Cicadettini took place in the relatively recent time, because in the pleistocene Evia was due to a low sea level a part of the continent. The evolution of mountain cicada species probably took place in the mountains. Later, when the sea level rose again, populations of cicadas on Evia became isolated by water from the mainland and speciated into endemic species.

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