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ORIGINAL ARTICLE

Two new species of *Cicadatra* (Hemiptera: Cicadoidea) from Greece

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Abstract

The present study is the description of two new species of *Cicadatra* Kolenati, 1857 found in some Greek islands during the summers of 1998 and 2001. *Cicadatra icari* **sp. n.** is described from Ikaria and Samos and *Cicadatra karpathosensis* **sp. n.** from Karpathos. Description of the external morphology is provided. The male genitalia were dissected for close examination and illustration. Acoustic signals produced by males were recorded and analyzed and a description of the calling songs is provided. Discrimination from the closely allied species is also provided.

Key words: calling song, cicadas, morphology, taxonomy

INTRODUCTION

Cicadas constitute the superfamily Cicadoidea, a group of the Hemiptera Auchenorrhyncha where males typically communicate during pair formation and courtship through acoustic distinctive signals (Claridge 1985; Boulard & Mondon 1995; Quartau *et al*. 1999; Simões *et al*. 2000). These striking acoustic signals make them an easily recognized group of insects. However, despite being common and usually medium to large insects, cicadas are not easily seen in the field and the taxonomy and biology of the group are in general still poorly known. This is the case of the Mediterranean region, notwithstanding the considerable effort that has been made by different authors in studying this cicadofauna, such as Sueur *et al*. (2004) for Portugal, Puissant and Sueur (2010) for Spain, Sueur and Puissant (2007) for France, Hertach (2011) for Italy, Gogala and Drosopoulos (2007), Gogala *et al*. (2008, 2009, 2011) for Greece, Gogala *et al*. (2006) for Macedonia, and Puissant and Sueur (2002) for Turkey.

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Along the Mediterranean basin, the Aegean Sea islands and the Balkans constitute a high diversity area which offered a number of important refugia during the last glacial period, and hence where several taxa might have evolved and from where species might have dispersed, namely in Europe (e.g. Oosterbroek 1994; Taberlet *et al*. 1998; Hewitt 1999; Çiplak 2004; Augustinos *et al*. 2005). However, only sporadic attention has been given to cicadas of this area, namely to species of the genera *Cicada* Linnaeus, 1758 (e.g. Quartau & Simões 2005; Simões & Quartau 2007), *Cicadetta* Kolenati, 1857 (Gogala & Drosopoulos 2007; Gogala *et al*. 2008, 2009, 2011) and *Tettigetta* Kolenati, 1758 (Boulard 2000; Trilar & Gogala 2010). In fact, despite the presence of some other genera in the region, very little is known about their species as is the case for species of the genus *Cicadatra* Kolenati, 1857.

With a wide geographic distribution, *Cicadatra* is one of the largest cicada genera in the Mediterranean area, with more than 40 species already known. In recent years some new species were described from nearby Iran (Mozaffarian & Sanborn 2010; Mozaffarian *et al*. 2010), but in Greece only four species and three subspecies of *Cicadatra* have been recorded so far: *C. alhageos* (Kolenati, 1857), *C. atra atra* (Olivier, 1790), *C. atra hyalinata* (Brullé, 1832), *C. atra vitrea* (Brullé, 1832), *C. platyptera* Fieber, 1876 and *C. hyalina* (Fabricius,

1798) (Nast 1972; Drosopoulos 1980; Boulard 1992; Mozaffarian & Sanborn 2010).

The present study is based on fieldwork carried out by two of the authors on different Greek islands (Samos and Ikaria, JAQ) and (Karpathos, PCS). During these trips several specimens were collected and the acoustic signals produced by males recorded. Analysis of the morphological and acoustic data revealed the presence of two new species, descriptions of which are here presented along with notes on their biology.

MATERIAL AND METHODS

Adults of the *Cicadatra* species were collected in summer during fieldwork carried out in several Greek islands. A total of twelve islands were visited, with the specimens here studied found on Samos and Ikaria (1998) and on Karpathos (2001). Males were first located by their acoustic signals. Their songs were recorded and insects were finally collected. Recordings were made during the warmest hours of the day, at ambient temperatures that ranged from 29 to 33°C using a Sony Dat recorder TCD-D10 ProII (sampling frequency 48 kHz, frequency response 20–22 kHz) with a Sony microphone F-780 (frequency response 22–50 kHz) following the procedures given in Quartau *et al.* (1999). Acoustic recordings are kept with one of the authors (JAQ) in the general data bank on insect acoustic data, which he has maintained since 1988.

Sound recordings were analyzed in time and frequency domains and shown as oscillograms, sonograms and spectra using Avisoft Sas-Lab Pro software (Specht 2002) as in previous analyses (Quartau *et al.* 1999, 2000; Simões *et al.* 2000). In the frequency domain, spectra were computed with a resolution of 512 points of FFT-length and a hamming window. For each male, recordings of about one minute were analyzed. Song terminology follows that of Gogala and Trilar (1999, 2000) and Gogala and Popov (2000).

Description of the general morphology is provided below. The male genitalia have been dissected and some of their structures illustrated, with emphasis given to the aedeagus. This is a structure of particular taxonomic interest since it provides useful morphological characters to discriminate species within the Auchenorrhyncha (e.g. Quartau 1981, 1988; Claridge *et al.* 1997).

Specimens are deposited in the Instituto de Investigação Científica Tropical, Lisbon (IICT), the Quartau collection (JAQC) and the Sanborn collection (AFSC).

RESULTS

The higher classification proposed by Lee and Hill (2010) is followed.

Taxonomy

Family Cicadidae Latreille, 1802

Subfamily Cicadinae Latreille, 1802

Tribe Cicadatrini Distant, 1905

Genus *Cicadatra* Kolenati, 1857

Cicadatra icari sp. n. (Figs 1–3)

Type material

Greece. Holotype, male, Ikaria, 11.vii.1998, col. J.A. Quartau (IICT); paratype, female, Ikaria, 11.vii.1998, col. J.A. Quartau (IICT); remaining paratypes – Ikaria, 1 male, 11.vii.1998, col. J.A.Quartau (JAQC); 1 male, 12.vii.1998, col. J.A.Quartau (JAQC); Samos, 1 male, 14.vii.1998, col. J.A.Quartau (AFSC).

Etymology

The species is named after Icarus, son of Daedalus in the Greek mythology, from whom the name of the island was derived and where most of the specimens were collected.

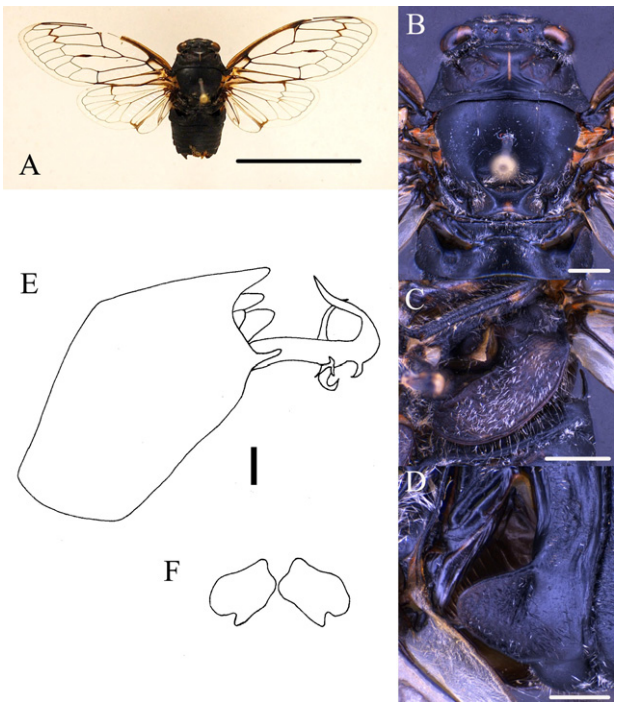

Figure 1 *Cicadatra icari* **sp. n.** (A) Paratype male habitus. (B) Paratype male dorsum. (C) Paratype male operculum. (D) Paratype male timbal cover. (E) Holotype male lateral view of genitalia. (F) Holotype male claspers. Scale for A = 2 cm, B–C = 2 mm, D = 1 mm, E–F = 0.05 mm.

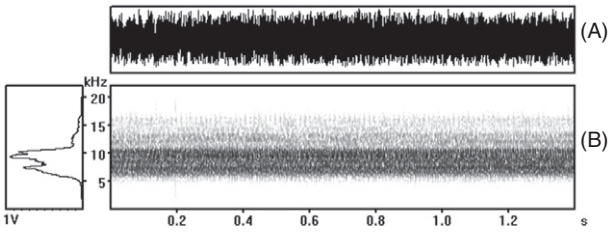

Figure 2 Continuous calling song of a male of *Cicadatra icari* **sp. n.** from Ikaria; (A) oscillogram and (B) sonogram of a selection of 1.4 s and amplitude spectra showing audible frequencies ranging from about 5 to 17 kHz with the maximum energy value at a frequency of 9.4 kHz.

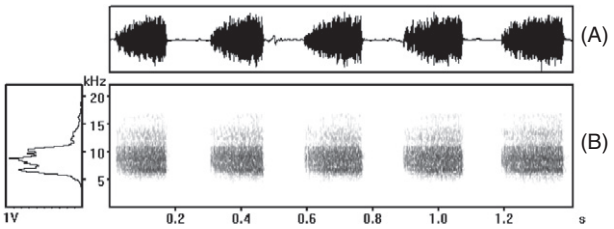

Figure 3 Short echeme song of a male of *Cicadatra icari* **sp. n.** from Ikaria; (A) oscillogram and (B) sonogram of a selection of 1.4 s and amplitude spectra showing audible frequencies of the song ranging from about 5 to 17 kHz with the maximum energy value at a frequency of 8.5 kHz.

Description

Coloration. Externally very similar to most congeneric species, with body from black to dark brown (Fig. 1A). In general structure and coloration similar in male and female.

Head (Fig. 1B). General color blackish brown. Head including eyes narrower than mesonotum but as broad as anterior margin of pronotum. Compound eyes brown to greenish brown and ocelli reddish. Postclypeus dark brown, sometimes light brown around transverse grooves. Anteclypeus, lora and genae dark brown. Mentum and labium brown. Short golden pile at the junction of the epicranial suture anterior arm and frontoclypeal suture. Long silvery pile on ventral head, lateral postclypeus and posterior to eye.

Thorax (Fig. 1B). Pronotum brown to dark brown with a well-defined longitudinal median yellow fascia. Pronotal disc paler than midline or collar. Pronotal collar generally blackish brown. Mesonotum shiny black or dark brown, sometimes an orangish line along parapsidal sutures. Cruciform elevation dark brown and generally light brown posteriorly. Short golden and long silvery pile between arms of cruciform elevation. Long silvery pile in wing grooves. Metanotum and ventral plates of thorax also dark brown.

Legs.Brown with brownish yellow longitudinal areas. Segments usually paler at base and darker towards apex. Forefemur with three large spines and sometimes with a fourth small apical spine. Primary spine longer and thicker than the remaining ones.

Operculum (Fig. 1C). Large, rounded, dark brown, not meeting medially.

Wings (Fig. 1A). Forewings hyaline and with brown to yellowish brown venation. Veins becoming darker distally. Median vein 3 + 4 particularly darker and thicker in males. Sometimes with a small infuscation in radiomedial and radial crossveins. Hind wings transparent and with veins brownish yellow, infuscation on radiomedial and radial crossveins of some paratypes.

Abdomen. With blackish brown tergites, abdominal sternites and epipleurites with dark brown color and with yellowish areas on lateral margins. Timbals with ten golden ribs and with dark brown, oval shape, incomplete timbal covers (Fig. 1D).

Male genitalia (Fig. 1E,F). Pygofer dark brown with dorsal beak defined as a spine and projecting beyond anal styles. Distal shoulder of the pygofer elongated in the form of a particularly thin spine. Pygofer without basal lobe. Uncus short. Brown claspers close to each other, almost meeting medially and becoming further apart distally (Fig. 1F). Aedeagus with apical appendages: one separate membranous expansion with four bending star-like spines, one of which is usually bigger than the remaining; two others much longer projections extend apically, the longest one with a claw-like appendage at its base.

Measurements. Length (measured from the apex of crown to tips of the tegmina in position of rest alongside the body): male, 29–31 mm (mean 30.0 mm; $n = 4$); female, 29 mm ($n = 1$); forewing length: male, 24–25 mm (mean 24.3; $n = 4$); female, 24 mm ($n = 1$); forewing width: male, 10–11 mm (mean 10.3; $n = 4$); female, 11 mm ($n = 1$); head width: male, 6–7 mm (mean 6.8; $n = 4$); female, 7 mm ($n = 1$); mesonotum width: male, 7–8 mm (mean 7.8; $n = 4$); female, 24 mm ($n = 1$).

Bioecological notes

Specimens were found on the islands of Ikaria and Samos and on many different unidentified trees or bushes.

Songs

This species has a calling song that can last without interruption for some minutes and which is made of a

continuous signal (Fig. 2). The dominant band of frequencies is found from about 5 to 17 kHz, with the highest energy value occurring at 9.4 kHz and a second frequency peak near 7 kHz (Fig. 2). Males could then change from this continuous signal to a short echeme song, consisting of echemes of increasing amplitude and which are regularly repeated (Fig. 3). In the recording that was analyzed, the number of pulse units has a mean value of 3.5 per second. The frequency spectrum ranges from about 5 to 17 kHz, with the highest energy value occurring near 8.5 kHz (Fig. 3).

Diagnosis

The new species *C. icari* **sp. n.** is rather similar to *C. atra atra* but differences in morphology, size, male genitalia and male acoustic signals can be found. In the new species, specimens are bigger than *C. atra atra*. Mean body length for *C. icari* **sp. n.** was 30 mm while in many *C. atra atra* specimens we collected in Greece (different places along the Peloponnese as well as in Skyros and Kithira islands, P. C. Simões, unpubl. data, 2002) the mean value was 25.7 mm. Boulard (1992) also gave a total length for *C. atra atra* of about 26.0–26.5 mm.

The main genital differences correspond to a different shape of the pygofer capsule, namely by the fact that in *C. icari* **sp. n.** the distal shoulder of the pygofer is a spine like structure which is lobe-like in *C. atra atra* (cf. Figs 1,6). Moreover, the claspers have also a different shape. In *C. icari* **sp. n.** the claspers meet medially and diverge distally, while in *C. atra atra* they meet more anteriorly and are not as separated at the posterior distal margin (cf. Figs 1,6). The pygofer capsule in the new species is also quite different from *C. hyalina* and *C. platyptera* since these do not have the spine-like distal shoulder and the aedeagus is also quite different in the apical appendages (see Schedl 1999). The subspecies of *C. atra* reported from Peloponnese can be differentiated by the thickening of median vein 2 in *C. atra vitrea* and the lack of infuscation in the radial and radiomedial crossveins of *C. atra hyalinata*.

Cicadatra icari **sp. n.** can also be readily distinguished morphologically from additional species of *Cicadatra* found in Turkey and the Middle East. *Cicadatra abdominalis* Schumacher, 1923, *C. alhageos* (Kolenati, 1857), *C. glycyrrhizae* (Kolenati, 1857) and *C. hagenica* Dlabola, 1987 all have a pale ground color (greenish or yellowish) rather than black and *C. tenebrosa* Fieber, 1876 has yellow markings on the dorsal pronotum and mesonotum and a yellow venter. *Cicadatra persica* Kirkaldy, 1909 is a larger species with lighter markings on the pronotum and mesonotum. *Cicadatra hyalina* can be differentiated by the greater marking on the pronotum and mesonotum along with the short claspers of the male. *Cicadatra adanai* Kartal, 1980 possesses yellow markings and the wing is short and wide (length : width, 1.8, ratio in *C. icari* about 2.4) and the long narrow wings and lack of an upper pygofer lobe differentiate *C. longipennis* Schumacher, 1923. Finally, *C. appendiculata* Linnavouri, 1954 found in Turkey, the Middle East and on Cyprus has a lighter body coloration, a curling upper pygofer lobe and a straight clasper.

Concerning the continuous calling song, the main differences correspond to the presence of a frequency peak at 9.4 kHz in *C. icari* **sp. n** and a second one near 7 kHz (Fig. 2), while in *C. atra atra* there is just one frequency peak at 9.8 kHz (Fig. 7). Likewise, there are clear differences in the short echeme song since in *C. icari* **sp. n.** echemes are repeated at a rate of 3.5 per second (Fig. 3), while in *C. atra atra* the repetition rate is 2.5 echemes per second (Fig. 8). Moreover, the peak frequency is 8.5 kHz in the new species while in *C. atra atra* is 9.8 kHz, which is also in agreement with the observations by Boulard (1992) for *C. atra atra*. On the other hand, *C. hyalina* was described by Boulard (1995) and Popov (1975) as having mainly a continuous time pattern calling song with a different range of frequencies and also different peak frequencies. In the case of *C. platyptera* the differences are even more clear since calling song of this species is a series of shorter individual syllables and the species produces wing clicks during short echeme song so that the species can be easily differentiated (Boulard 1995; Gogala *et al.* 2006).

Cicadatra karpathosensis sp. n. (Figs 4,5)

Type material

Greece. Holotype, male, Karpathos, 13.vii.2001, col. P. Simões (IICT); paratypes – Karpathos, 3 males, 13.vii.2001, col. P. Simões (one each IICT, JAQC, AFSC).

Etymology

The species name is derived from the name for the Greek island of Karpathos.

Description

Coloration. Ground color of the body black with brown marks, being externally very similar to the other species of *Cicadatra* (Fig. 4A). All collected specimens were males; females could not be captured but were observed to have similar appearance to the males.

Head (Fig. 4B). General color blackish brown. Head including eyes narrower than mesonotum and as broad as anterior margin of pronotum. Compound eyes brown to dark brown and with red-orangish ocelli. Postclypeus and anteclypeus brown to dark brown. Lora, genae,

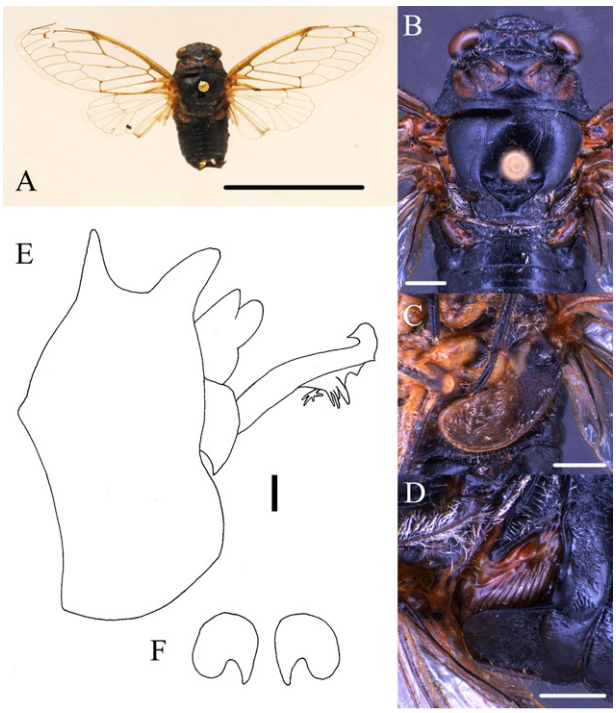

Figure 4 *Cicadatra karpathosensis* **sp. n.** (A) Paratype male habitus. (B) Paratype male dorsum. (C) Paratype male operculum. (D) Paratype male timbal cover. (E) Holotype male lateral view of genitalia. (F) Holotype male claspers. Scale for A = 2 cm, B–C = 2 mm, D = 1 mm, E–F = 0.05 mm.

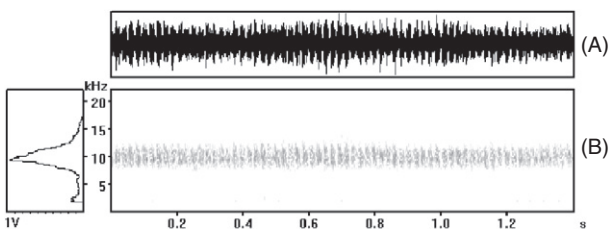

Figure 5 Calling song of a male of *Cicadatra karpathosensis* **sp. n.** from Karpathos; (A) oscillogram and (B) sonogram of a selection of 1.4 s. and amplitude spectra showing audible frequencies of the calling song ranging from about 5 to 17 kHz with the maximum energy value at a frequency of 9.6 kHz.

mentum and labium brown. Long silvery pile on ventral head and posterior to eye.

Thorax (Fig. 4B). Pronotum brown to dark brown, disc lighter than midline and collar, sometimes with a very thin brown longitudinal median line. Pronotal collar blackish brown. Mesonotum shiny black or dark brown. Cruciform elevation totally dark brown as well as metanotum. Long silvery pile between arms of cruciform elevation and along wing grooves. Ventral plates of thorax dark brown.

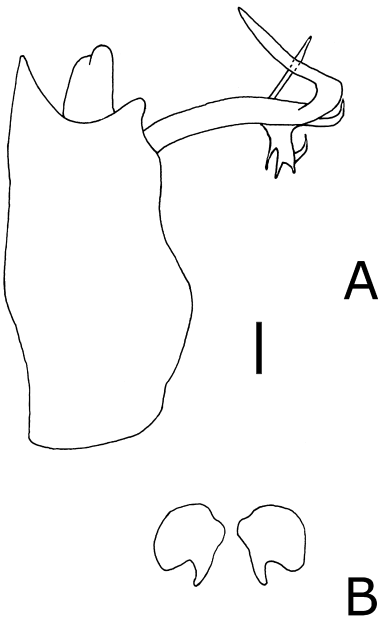

Figure 6 *Cicadatra atra* specimen from Skyros; male genitalia. (A) Pygofer, Xth segment and aedeagus, left lateral view. (B) Male claspers, posterior view. Scale = 0.05 mm.

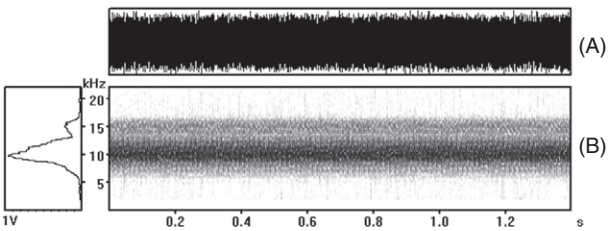

Figure 7 *Cicadatra atra* continuous calling song of a male of from Skyros; (A) oscillogram and (B) sonogram of a selection of 1.4 s. and amplitude spectra showing audible frequencies ranging from about 5 to 17 kHz with the maximum energy value at a frequency of 9.8 kHz.

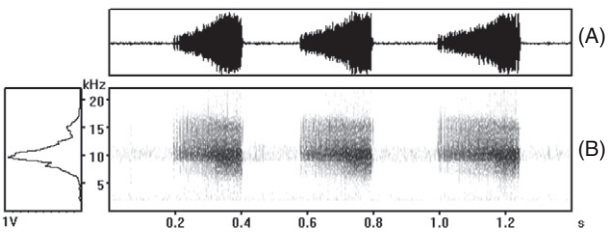

Figure 8 *Cicadatra atra* short echeme song of a male of from Skyros; (A) oscillogram and (B) sonogram of a selection of 1.4 s. and amplitude spectra showing audible frequencies of the calling song ranging from about 5 to 17 kHz with the maximum energy value at a frequency of 9.8 kHz.

Legs. Brown with brownish yellow longitudinal areas, particularly on the ventral side. Forefemur with three large spines. Primary spine bent, longer and thicker than the remaining ones.

Operculum (Fig. 4C). Large, rounded, brownish yellow in color and not meeting medially.

Wings. Forewings hyaline with brown to yellowish brown venation. Veins becoming darker distally. No veins particularly darker or thicker than others. A small infuscation in radiomedial and radial crossveins. Hind wings transparent with brownish yellow veins.

Abdomen. With blackish brown tergites, sternites and epipleurites. Timbals with ten golden ribs oval shaped, timbal covers dark brown in color, incomplete (Fig. 4D).

Male genitalia (Fig. 4E,F). Pygofer dark brown, dorsal beak defined as a spine and projecting beyond the anal styles. The distal shoulder of the pygofer particularly large, globate and larger than the dorsal beak. Pygofer without basal lobe. Uncus short. Claspers brown, closer at base and curving laterally and distally (Fig. 4F). Stem of aedeagus long with two sub-apical appendages: one membranous with four small spines more or less of the same size; another extremely thin and ramified. In the upper extreme of aedeagus there is an asymmetrically bilobed structure ending in a claw-like shape.

Measurements. Length (measured from the apex of crown to tips of the tegmina in position of rest alongside the body): male, 28–33 mm (mean 30.5 mm; $n = 4$); forewing length: male, 22–25 mm (mean 24.0; $n = 4$); forewing width: male, 8–10 mm (mean 9.3; $n = 4$); head width: male, 6–7 mm (mean 6.3; $n = 4$); mesonotum width: male, 7–8 mm (mean 7.8; $n = 4$).

Bioecological notes

Possibly endemic to the island of Karpathos. Adults, associated with the macchia habitat. It was also found on bushes and trees such as *Pistacea lentiscus* (Family Anacardiaceae), *Prunus persica* (Family Rosaceae) and *Pinus halepensis* (Family Pinaceae).

Songs

Usually the male lifts up the abdomen and starts the calling song, which constitutes a continuous signal. Under a time magnification the calling signal shows pulse units: of a total of nine analyzed recordings the number of pulse units per second ranged from 42 to 49 with a mean value of 46/sec. It shows a dominant band of frequencies from about 5 to 17 kHz, with the highest energy value occurring at 9.6 kHz (Fig. 5).

Diagnosis

Males of *C. karpathosensis* **sp. n.** may be distinguished from closely related species (see Boulard 1992; Schedl 1999) by unique characters of the male genitalia. The distal shoulder of the pygofer claspers and the aedeagus are very different from all other species present in Greece. Figure 6 shows the particularly large and globate distal shoulder of the pygofer. In addition, the claspers are closer at the base and are curved laterally and distally. The stem of the aedeagus is long and with characteristic apical appendages: one forming a separate membrane with four small spine-like appendages more or less of the same size; a second one is a thin and ramified lateral appendage and finally at the upper extreme of the aedeagus there is an asymmetrically bilobed structure ending in a claw-like shape. In addition, *C. karpathosensis* **sp. n.** lacks the thickening of median vein 2 found in *C. atra vitrea* and the lack of infuscation in the radial and radiomedial crossveins in *C. atra hyalinata*, which have been reported from the Peloponnese.

Cicadatra karpathosensis **sp. n.** can also be readily distinguished morphologically from additional species of *Cicadatra* found in Turkey and the Middle East. *Cicadatra abdominalis*, *C. alhageos*, *C. glycyrrhizae* and *C. hagenica* all have a light ground color (greenish or yellowish) rather than black and *C. tenebrosa* has yellow markings on the dorsal pronotum and mesonotum and a yellow venter. *Cicadatra persica* is a larger species with lighter markings on the pronotum and mesonotum. *Cicadatra hyalina* can be distinguished by the greater marking on the pronotum and mesonotum along with the short claspers of the male. *Cicadatra adanai* possesses yellow markings and the wing is short and wide (length : width 1.8, ratio in *C. karpathosensis* about 2.6) and the long narrow wings and lack of an upper pygofer lobe differentiate *C. longipennis*. Finally, *C. appendiculata* found in Turkey, the Middle East and on Cyprus has lighter body coloration, a curling upper pygofer lobe and a straight clasper.

Analysis of the calling song reveals a peak frequency of 9.6 kHz and a pulse repetition frequency of 46 per second. This repetition rate is quite different from the continuous pattern present in *C. atra atra* (Fig. 7). Moreover, the new species is also clearly differentiated from *C. hyalina* (see Boulard 1995; compare also http://www.cicadasong.eu/cicadidae/cicadatra-hyalina.html) since it does not have the continuous time pattern calling song with two different peak frequencies. It can be discriminated from *C. platyptera* since the calling song of this species consists of clearly separated syllables and

wing clicks during courtship (Boulard 1995; Gogala *et al*. 2006).

DISCUSSION

This study adds two new species to the highly diverse genus *Cicadatra*. The new species are morphologically similar to the *Cicadatra* species known to occur in Greece: *C. alhageos*, *C. atra*, *C. platyptera* and *C. hyalina* (Nast 1972; Boulard 1992; Mozaffarian & Sanborn 2010). However, despite a very similar appearance, there are consistent differences in the structure of the aedeagus, as well as in the male calling songs. It is likely that the distribution of the new species may be restricted to the islands where specimens were found.

The current species list available for the cicadas from Greece (Drosopoulos 1980) is certainly very incomplete, since the fauna is still poorly known. As this country occupies a central place in the Mediterranean region and has clusters of isolated islands, it is a potential hot-spot for general biodiversity, including cicadas, and possibly is also characterized by a high rate of endemism. As the male acoustic signals in cicadas contain in many instances the main characters enabling separation of closely related species (Claridge 1985; Boulard & Mondon 1995; Quartau & Simões 2006; Gogala *et al*. 2008, 2009, 2011), it is quite possible that to the same specific name may correspond in fact two or more independent sibling species as it happens in other genera, such as *Cicadetta* (e.g. Gogala *et al*. 2008, 2009, 2011) and *Tettigetta* (e.g. Puissant & Sueur 2010). Moreover, there are also several species of other genera in neighboring countries that have not yet been found in Greece. All this suggests the presence of a larger number of species in Greece than those already known and calls for further cicada surveys in the area. This research also suggests a better knowledge of the cicada biology and ecology is also the key for the conservation of these interesting insects in the Mediterranean.

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REFERENCES

Augustinos AA, Mamuris Z, Stratikopoulos EE, Amelio SD, Zacharopoulo A, Mathiopoulos KD (2005) Microsatellite analysis of olive fly populations in the Mediterranean indicates a westward expansion of the species. *Genetica* **125,** 231–241.

Boulard M (1992) Identité et bio-écologie de *Cicadatra atra* (Olivier, 1790), la cigale noir, in Gallia Primordia Patria (Homoptera, Cicadoidea; Cicadidae). *EPHE Biologie et Evolution des Insectes* **5,** 55–86.

Boulard M, Mondon B (1995) *Vies & Mémoires de Cigales*. Équinoxe, Barbentane.

Boulard MM (1995) Postures de cymbalisation, cymbalisations et cartes d'identité acoustique de cigales. 1 Généralités et espèces méditerranéennes (Homoptera, Cicadoidea). *EPHE Biologie et Evolution des Insectes* **7/8,** 1–72.

Boulard MM (2000) Description de quatre *Tettigetta* ibériques nouvelles (Auchenorhyncha, Cicadidae, Tibicinae). *EPHE Biologie et Evolution des Insectes* **13,** 133–143.

Çiplak B (2004) Systematics, phylogeny and biogeography of Anterastes (Orthoptera, Tettigoniidae, Tettigoniinae): evolution within a refugium. *Zoologica Scripta* **33,** 19–44.

Claridge MF (1985) Acoustic signals in the Homoptera: behavior, taxonomy, and evolution. *Annual Review of Entomology* **30,** 297–317.

Claridge MF, Dawah HA, Wilson MR (1997) Species in insect herbivores and parasitoids – sibling species, host races and biotypes. In: Claridge MF, Dawah HA, Wilson MR (eds) *Species: The Units of Biodiversity*, pp 247–272. Chapman & Hall, London.

Drosopoulos S (1980) Hemipterological studies in Greece. Part II. Homoptera-Auchenorrhyncha. A catalogue of the reported species. *Biologia Gallo-Hellenica* **9,** 187–194.

Gogala M, Drosopoulos S (2007) Song of *Cicadetta flaveola* Brullé (Auchenorrhyncha: Cicadoidea: Tibicinidae) from Greece. *Russian Entomological Journal* **15,** 275–278.

Gogala M, Drosopoulos S, Trilar T (2008) *Cicadetta montana* complex (Hemiptera, Cicadidae) in Greece – a new species and new records based on bioacoustics. *Deutsche Entomologische Zeitschrift* **55,** 91–100.

Gogala M, Drosopoulos S, Trilar T (2009) Two mountains, two species: new taxa of the *Cicadetta montana* species complex in Greece (Hemiptera: Cicadidae). *Acta Entomologica Slovenica* **17,** 13–28.

Gogala M, Popov AV (2000) Bioacoustics of the singing cicadas of the western Palaeartic: *Tettigetta dimissa* (Hagen) (Cicadoidea: Tibicinidae). *Acta Entomologica Slovenica* **8,** 7–20.

Gogala M, Trilar T (1999) The song structure of *Cicadetta montana macedonica* Schedl with remarks on songs of related singing cicadas (Hemiptera: Auchenorrhyncha: Cicadomorpha: Tibicinidae). *Reichenbachia Staatliches Museum für Tierkunde Dresden* **33,** 91–97.

Gogala M, Trilar T (2000) Sound emissions of *Pagiphora annulata* (Homoptera: Cicadoidea: Tibicinidae) – A preliminary report. *Acta Entomologica Slovenica* **8,** 21–26.

Gogala M, Trilar T, Drosopoulos S (2011) Two new species and a new genus of Cicadettini (Hemiptera, Cicadidae) from the Greek island of Evia. *Mitteilungen aus dem Museum für Naturkunde im Berlin, Deutsche Entomologische Zeitschrift* **58,** 105–117.

Gogala M, Trilar T, Krpac VT (2006) Fauna of singing cicadas (Auchenorrhyncha: Cicadoidea) of Macedonia – a bioacousticc survey. *Acta Entomologica Slovenica* **13,** 103–126.

Hertach T (2011) Spectacular song pattern from the Sicilian Mountains: The new cicada species *Cicadetta anpaistica* sp. n. (Hemiptera: Cicadidae). *Zootaxa* **2771,** 25–40.

Hewitt GM (1999) Post-glacial re-colonization of European biota. *Biological Journal of the Linnean Society* **68,** 87–112.

Lee YJ, Hill KBR (2010) Systematic revision of the genus *Psithyristria* Stål (Hemiptera: Cicadidae) with seven new species and a molecular phylogeny of the genus and higher taxa. *Systematic Entomology* **35,** 277–305.

Mozaffarian F, Sanborn AF (2010) The cicadas of Iran with the description of two species (Hemiptera, Cicadidae). *Deutsche Entomologische Zeitschrift* **57,** 69–84.

Mozaffarian F, Sanborn AF, Phillips PK (2010) *Cicadatra lorestanica*, a new species of cicada from Iran (Hemiptera: Cicadidae). *Journal of Entomological and Acarological Research* **42,** 27–37.

Nast J (1972) *Palaeartic Auchenorrhyncha (Homoptera), an Annoted Checklist*. Polish Scientific Publications, Warszawa.

Oosterbroek P (1994) Biodiversity of the Mediterranean region. *Systematics and Conservation Evaluation* **50,** 289–307.

Popov AA (1975) The structure of the tymbals and the characteristics of the sound signals in singing cicadas (Homoptera, Cicadidae) in the southern regions of the USSR. *Entomological Review* **52,** 7–35.

Puissant S, Sueur J (2002) Description of a new cicada species from Turquey (Hemiptera, Cicadoidea). *Revue française d'Entomologie* **24,** 197–200.

Puissant S, Sueur J (2010) A hotspot for Mediterranean cicadas (Insecta: Hemiptera: Cicadidae): new genera, species and songs from southern Spain. *Systematics and Biodiversity* **8,** 555–574.

Quartau JA (1981) New and redescribed species of African *Batracomorphus* Lewis (Homoptera: Cicadellidae), with a key to all known Ethiopian species. *Memoirs of the Entomological Society of Southern Africa* **14,** 1–134.

Quartau JA (1988) A numerical taxonomic analysis of interspecific morphological differences in two closely related species of *Cicada* (Homoptera, Cicadidae) in Portugal. *Great Basin Naturalist Memoirs* **12,** 171–181.

Quartau JA, Rebelo MT, Simões PC *et al.* (1999) Acoustic signals of populations of *Cicada orni* L. in Portugal and Greece (Homoptera: Auchenorrhyncha: Cicadidae). *Reichenbachia Staatliches Museum für Tierkunde Dresden* **33,** 71–80.

Quartau JA, Seabra S, Sanborn A (2000) Effect of ambient air temperature on the calling song of *Cicada orni* Linnaeus, 1758 (Hemiptera: Cicadidae) in Portugal. *Acta Zoologica Cracoviensia* **43,** 193–198.

Quartau JA, Simões PC (2005) *Cicada cretensis* sp. n. (Hemiptera, Cicadidae) from southern Greece. *Biologia* **60,** 489–494.

Quartau JA, Simões PC (2006) Acoustic evolutionary divergence in cicadas: the species of *Cicada* L. in southern Europe. In: Drosopoulos S, Claridge MF (eds) *Insect Sounds and Communication. Physiology, Behaviour and Evolution*, pp 227–237. Taylor & Francis, Boca Raton.

Schedl W (1999) Contribution to the singing cicadas of Israel and adjacent countries (Homoptera, Auchenorrhyncha: Cicadidae et Tibicinidae). *Linzer Biologische Beiträge* **31,** 823–837.

Simões PC, Boulard M, Rebelo MT *et al.* (2000) Differences in the male calling songs of two sibling species of *Cicada* (Hemiptera: Cicadoidea) in Greece. *European Journal of Entomology* **97,** 437–440.

Simões PC, Quartau JA (2007) Distribution patterns and calling song variation song in species of the genus *Cicada* Linnaeus, 1758 (Hemiptera, Cicadidae) in the Aegean Sea area. *Italian Journal of Zoology* **75,** 135–146.

Specht R (2002) Avisoft-SASLab Pro-Sound analysis and synthesis laboratory. A PC-software for MS-Windows 95/98/ME/NT/2000/XP. version 4.1d. Avisoft Bioacoustics, Berlin. [Cited 3 June 2002.] Available from URL: http://www.avisoft.com.

Sueur J, Puissant S (2007) Similar look but different song: a new *Cicadetta* species in the *montana* complex (Insecta, Hemiptera, Cicadidae). *Zootaxa* **1442,** 55–68.

Sueur J, Puissant S, Simões PC, Seabra S, Boulard M, Quartau JA (2004) Cicadas from Portugal: revised list of species with eco-ethological data (Hemiptera: Cicadidae). *Insect Systematics and Evolution* **35,** 177–187.

Taberlet P, Fumagalli L, Wust-Saucy AG (1998) Comparative phylodeography and postglacial colonization routes in Europe. *Molecular Ecology* **7,** 453–464.

Trilar T, Gogala M (2010) *Tettigetta carayoni* Bolard (Hemiptera. Cicadidae) from Crete, faunistic data and first description of its song. *Acta Entomologica Slovenica* **18,** 5–18.