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TWO MOUNTAINS, TWO SPECIES: NEW TAXA OF THE *CICADETTA MONTANA* SPECIES COMPLEX IN GREECE (HEMIPTERA: CICADIDAE)

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Abstract – On two mountains of Greece (Mt. Olymbos, Mt. Kissavos) in the eastern part of Thessalia, two new species of Cicadettini have been discovered. On Mt. Olymbos *Cicadetta olympica* sp. n. and on Mt. Kissavos *C. kissavi* sp. n. – both belonging to the *Cicadetta montana* species complex. On Mt. Kissavos we acoustically detected also *C. montana* s. stricto. Both new species have characteristic, species specific song patterns, which differ from all other species of the *C. montana* species complex. Morphologically however, both new species are very similar to other species of the *C. montana* species complex and to each other.

KEY WORDS: Hemiptera, Cicadidae, *Cicadetta montana* species complex, songs, singing cicadas

Izvleček – DVE GORI, DVE VRSTI: NOVA TAKSONA KOMPLEKSA VRST *CICADETTA MONTANA* V GRČIJI (HEMIPTERA: CICADIDAE)

Na dveh grških gorah (Olimp in Kissavos) v vzhodnem delu Tesalije smo našli dve novi vrsti iz skupine Cicadettini. Iz Olimpa opisujemo olimpskega gorskega škržada (*Cicadetta olympica* sp. n.) in iz Kissavosa kisavoškega gorskega škržada (*C. kissavi* sp. n.), ki oba pripadata kompleksu vrst gorskega škržada (*C. montana*). Na Kissavosu smo akustično zaznali tudi Skopolijevega gorskega škržada (*C. montana* s. str.). Obe novi vrsti imata značilen, vrstno specifičen napev, ki se razlikuje

od vseh ostalih vrst iz kompleksa vrst gorskega škržada. Morfološko sta obe novi vrsti zelo podobni druga drugi in tudi ostalim vrstam iz tega kompleksa.

KLJUČNE BESEDE: Hemiptera, Cicadidae, kompleks vrst *Cicadetta montana*, petje, pojoči škržadi

Introduction

During the last twenty years it became evident, that bioacoustic analyses are very useful in investigation of cicada taxonomy (Cicadidae, sensu Moulds 2005). Many new species were described and species complexes recognized worldwide (e.g. Alexander & Moore 1958; Cooley & Marshall 2001; Ewart 2005; Boulard 2006a, 2006b; Quartau & Simões 2006). This is true also for European cicadas, especially for the *Cicadetta montana* species complex (e.g. Gogala & Trilar 1999, 2004; Gogala et al. 2008; Puissant & Boulard 2000; Sueur & Puissant 2007a, 2007b; Hertach 2007).

There is still no comprehensive paper on the Cicadidae of Greece. Recently, we published the description of a new species of "mountain cicada" *C. hannekeae* Gogala, Drosopoulos et Trilar 2008, which is endemic to Greece. It is widely distributed in the mountains from the Peloponesos through the Greek mainland, northwards up to the 40° latitude. In northern Greece and adjacent countries, other species of the *C. montana* species complex are present, mainly *C. macedonica* Schedl 1999 and *C. montana* s. stricto (Gogala et al. 2005, 2008). However, the fauna of mountain cicadas and related species was not investigated with bioacoustic methods along the Eastern coast of the Greek mainland till now. Therefore, we devoted during our investigations special attention to the *Cicadetta montana* complex of species in this region.

Materials and methods

We made field trips to Thessalia in the eastern part of the Greek mainland in the year 2007. The field trip to Mt. Olymbos (2917 m) occurred on July 6th, 2007 and that to Mt. Kissavos (1978 m) on July 7th, 2007. The distance between highest peaks of both mountains is 42.5 km and they are divided by the deep Tembi valley (10-50 m ASL) with the river Pinios.

For the names and spelling of localities we follow the transliterations used in the maps of "Road Editions", Athens.

The ambient temperature at both localities (around 1000 m above sea level) was during our recordings between 20-25°C.

For acoustic detection and recording of songs we used the following equipment: two ultrasonic detectors Pettersson D-200 with microphones mounted in front of a Telinga reflector (57 cm diameter) or smaller metal reflector (15 cm diameter) connected to the solid state recorders Marantz PMD-670 or PMD-660. For sound analyses we used Raven 1.3 (Cornell Lab of Ornithology), Amadeus Pro 1.3 (HairerSoft) and Seewave

package (Sueur et al. 2008) as a part of R statistic software. We first localized cicadas acoustically 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 type material is deposited in the collection of the Slovenian Museum of Natural History (PMSL). Song samples are available on the Web site: <http://www.cicadasong.eu>.

Results

Cicadetta olympica Gogala, Drosopoulos & Trilar sp. n.

We visited Mt. Olymbos on July 6th, 2007 and recorded the song pattern of this species at two localities, Prionia (1050 m) and Stavros (950 m). In both localities we detected many males with the same song pattern, made 32 recordings and collected two around Stavros.

Song pattern. The song pattern is very simple and resembles the calling song of *C. brevipennis* Fieber, 1876 (Gogala & Trilar 2004), but without the short echeme at the end of a phrase (Fig. 1). It comprises a series of long echemes, the duration of which is about 1.5 s and the interval between echemes is 0.6 s (Fig. 2). Even the amplitude profile is similar, the amplitude of the signal rising slowly, reaching the maximum at the first third of a phrase (Fig. 1). Statistic values are shown in Table 1. Carrier frequency maximum of the calling song is 12.8 kHz and the -20 dB range 7.9-15.7 kHz.

Table 1: Statistic data of the calling song echeme and interval duration of *Cicadetta olympica* sp. n. (LE – long echeme).

	LE duration (s)	Interval (s)
N	675	643
Mean	1.56	0.63
St.Dev.	0.47	0.24
Median	1.42	0.62
1Quartil	1.29	0.47
3Quartil	1.64	0.70
Min.	0.89	0.17
Max.	3.42	3.14

Morphology

Specimens examined. Holotype ♂: Greece: Mt. Olymbos, Stavros, 6.7.2007, 1004 m, 40°06'22" N, 22°27'33.4" E, Leg. M. Gogala, T. Trilar

Paratype ♂: Greece: Mt. Olymbos, Stavros, 6.7.2007, 942 m, 40°06'43.3" N, 22°28'01.8" E, Leg. T. Trilar, M. Gogala.

Description. We can only describe the habitus of the two **males**, which resemble that of the other species of *C. montana* s. lato.

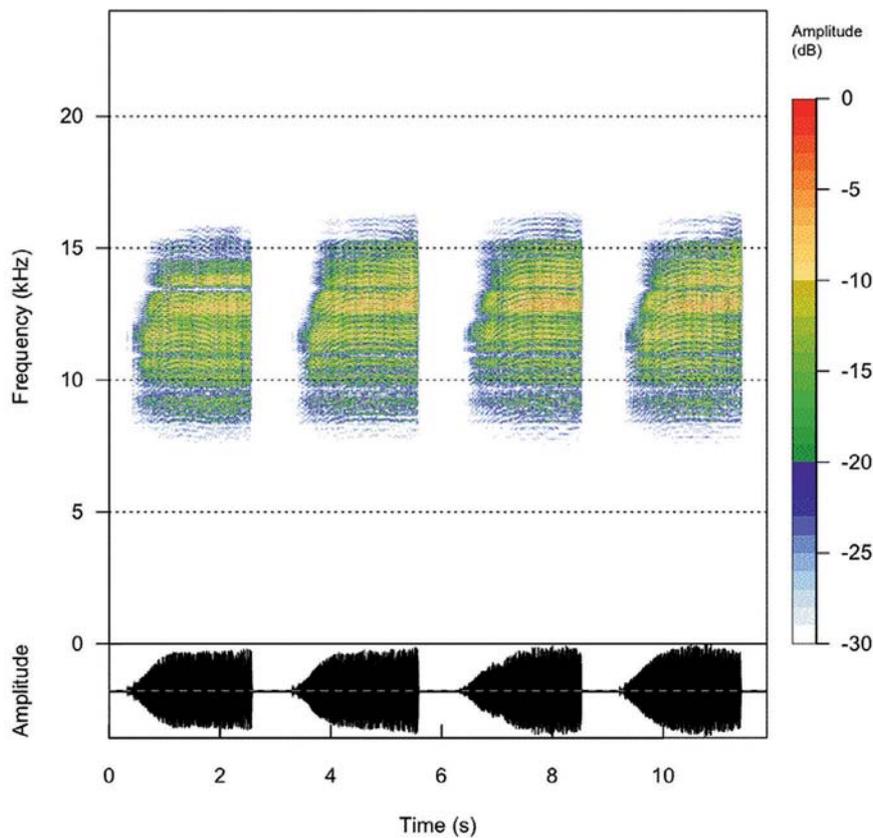


Fig. 1: Spectrogram and oscillogram (below) of the calling song of *Cicadetta olympica* sp. n. - The R and Seewave software was used to produce this graph.

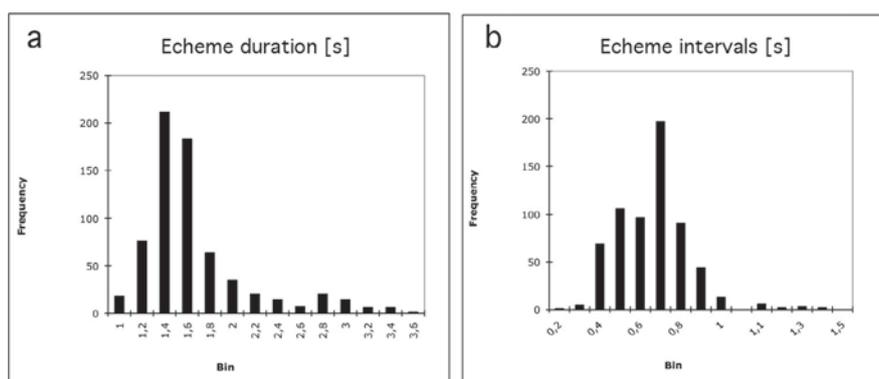


Fig. 2: Histograms showing the distribution of the echeme duration (a) and interval duration (b) of the calling song of *Cicadetta olympica* sp. n. (N=32).

Matija Gogala, Sakis Drosopoulos, Tomi Trilar: Two mountains, two species: new taxa of the *Cicadetta montana* species complex

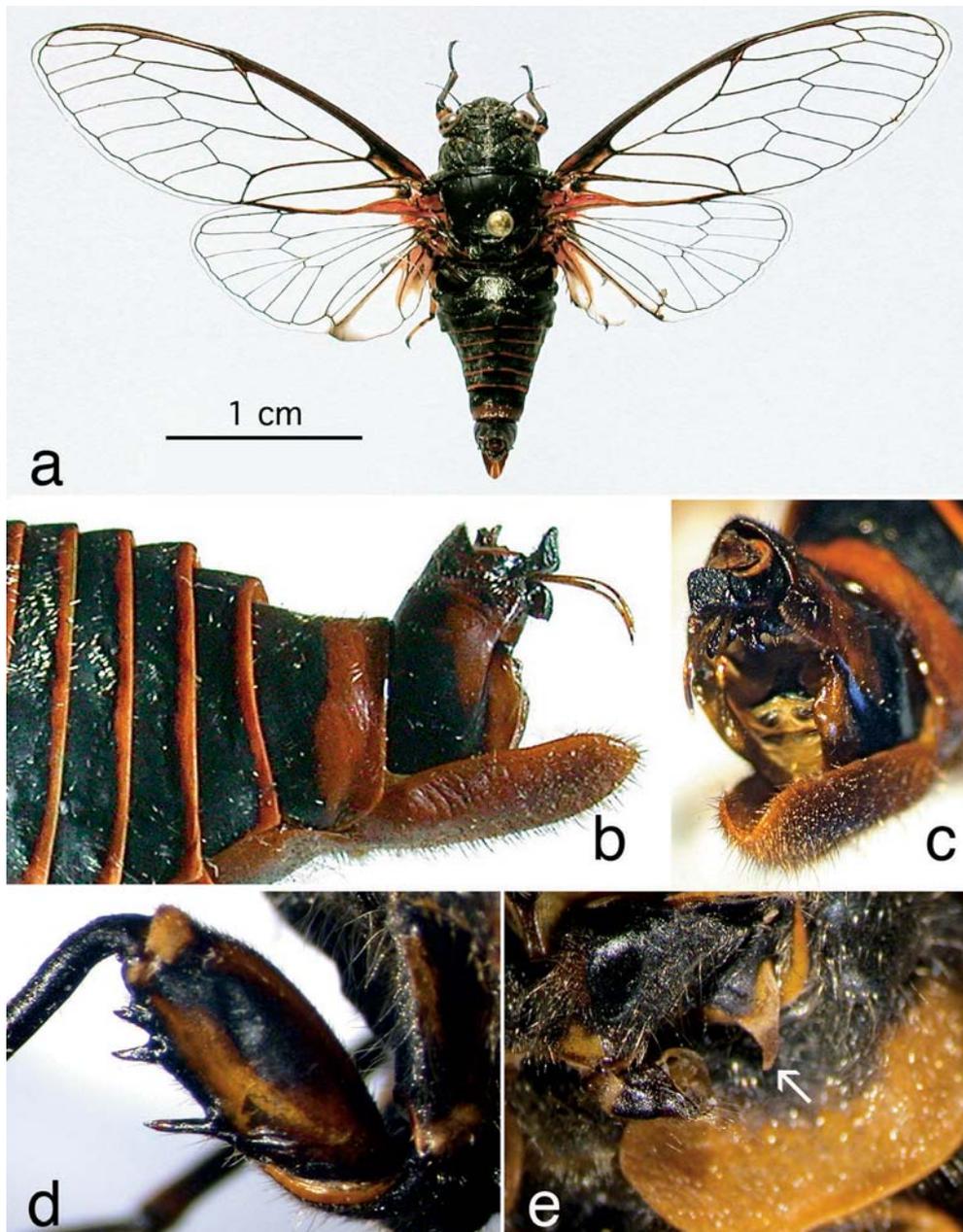


Fig. 3: Morphology of *Cicadetta olympica* sp. n.: a – habitus of a male (holotype); b – lateral view of male genitalia, c – view of male genital capsule from behind, uncus, claspers and parts of aedeagus can be seen; d – front femora with three spines; e – left operculum with flat meracanthus (marked with arrow).

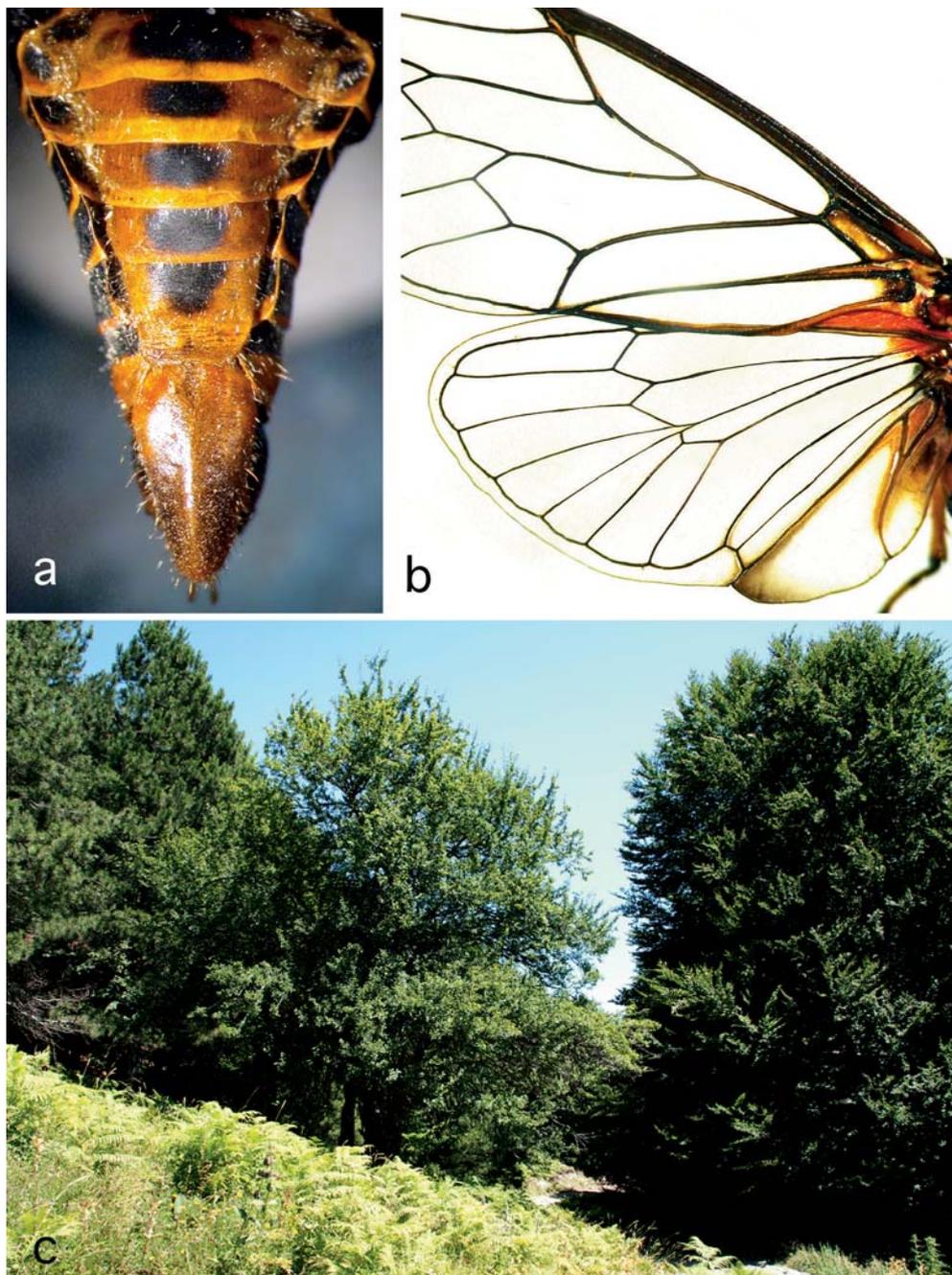


Fig. 4: Morphology and habitat of *Cicadetta olympica* sp. n., holotype: a – abdominal sternites; b – wing venation; c – typical habitat.

The body length from the head to the tip of the abdomen is 19.4 and 19.5 mm, the tegmina in males measure in length 20.4 and 21 mm and in width 8 and 8.2 mm.

The overall coloration is black with yellow, orange-red and brown markings (Fig. 3a).

The head is black, with a yellow patch on the epicranial suture. The holotype is darker, the paratype lighter. Supra-antennal plates brown, in paratype yellow. Postclypeus laterally yellow, rostrum reaching the tip of middle coxae. Pronotum black, in paratype with a narrow median yellow line distally, hind edge with light brown rim laterally. Lateral angles of pronotal collar pronounced. Mesonotum black, in paratype two brown patches at the end of parapsidal suture. Scutum and cruciform elevation black, mesonotal posterior ridge near the wing groove and metanotum basilaterally and posteriorly yellow.

Abdominal tergum 1 in front of tymbals with brown markings, tymbal with a tymbal plate, 3 long and 1 short ribs. Terga 3 through 7 black with broad reddish brown borders, only medial dorsal ridge more or less black.

Pygophor (Figs. 3b, c) with dorsal beak in the form of a gothic broken arc and distinct flat protruding upper lobes of pygophor. Basal lobes touching the main capsule. Median lobe of uncus pronounced, broadly rounded and black, claspers flat and dark brown, hooked anterolaterad, pseudoparamers long and slightly flattened, with sharp points. Basal plate of aedeagus broadly Y-shaped (Fig. 3c).

Ventral side black with yellow to reddish brown markings. Front femora with three spines (Fig. 3d), tibiae and tarsi yellow and black coloured. Opercula basally dark, distally yellow, broadly rounded, not overlapping, with flattened yellow spine (meracanthus) (Fig. 3e – marked with arrow). Abdominal sternites medially dark (in paratype yellow), distal and lateral edges broadly yellow brown. Sternite VIII yellow, 2 and 2.2 times longer than the median length of sternite VII (Fig. 4a). Abdominal segments triangular in cross section, dorsally forming a rounded ridge. Episterna dark with distal edges yellow brown.

Tegmina and hind wings transparent, without markings, with exception of brightly coloured basal parts (Fig. 4b). The number of apical cells on front wings is 8 and on hind wings 6. Ulnar cell 1 much longer than apical cell 1 (1.3 and 1.6 times). Median and anterior cubitus vein originating in one point at the basal cell. Basal cell of first wing dark brown or yellow, frontally much darker than caudally. Basal membrane reddish as well as the base of the costal cell of hind wings. Veins dark brown to black. Costal vein dark brown, subcosta lighter brown. Medial and cubitus anterior veins till nodal line yellow brown. Distal veins on tegmina and veins of hind wings black.

Ecology. Individuals of *C. olympica* sp. n. were found on various coniferous and deciduous trees and shrubs in the altitudes around 1000 m ASL (Fig. 4c). The density of the singing males was not very high. From the most suitable recording positions we were able to detect up to three animals. We did not detect any other species of *C. montana* s. lato at these localities. However, we recorded at the locality Stavros also *Dimissalna* (= *Tettigetia dimissa*), *Cicadatra atra* and heard also *Cicada orni*, *Lyristes plebejus* and *Tettigetia brullei*.

***Cicadetta kissavi* Gogala, Drosopoulos & Trilar sp. n.**

The neighbouring mountain to Mt. Olymbos is Mt. Kissavos, called also Mt. Ossa. There we acoustically detected a new song pattern and collected 2 specimens, one male and

one female, approaching a singing male. The altitude of the localities with this new species was between 1000 and 1150 m.

Song pattern. The song consists of series of short and long echemes in a specific pattern (Figs. 5 and 6). The duration of the short echemes is about 30 ms and the intervals in between about 80 ms. After some time, this pattern switches to a sequence of long echemes with duration of 160-210 ms and intervals of 370-650 ms (Table 2, Figs. 5, 6 and 7). Then the first pattern appears again or the song ends with a longer pause. The new song sequence starts at least in some cases with an introductory long echeme (duration: 1.3 and 1.85 s), followed by a pattern described above. Exact data are given in Table 2. The number of long echemes per group nested in a long sequence of short echemes may vary between 1 and 30. Sometimes a sequence of long echemes is interrupted by 1 or 2 short echemes.

The carrier frequency of this song has typically a maximum near 13.1 kHz and the -20 dB range is between 9.3 and 16.6 kHz.

Table 2: Statistic data on the short echeme and long echeme duration and the intervals between them of *Cicadetta kissavi* sp. n. (SE – short echeme, LE – long echeme, INTV – interval).

	SE (ms)	LE (ms)	INTV SE (ms)	INTV LE (ms)
N	3348	593	3303	613
Mean	29.9	198.6	82.4	520.3
St.Dev.	5.4	95.2	39.6	218.6
Median	29.6	188.0	79.5	528.2
1Quartil	27.0	163.8	73.0	368.0
3Quartil	32.2	212.0	86.1	653.7
Min.	0.9	27.9	7.5	32.7
Max.	95.7	1282.8	949.6	2133.8

Morphology

Specimens examined. Holotype ♂: Greece: Mt. Kissavos, Anatoli, 7.7.2007, 1023 m, 40°46'10.4" N, 22°27'33.4" E, Leg. T. Trilar, M. Gogala.

Paratype ♀: Greece: Mt. Kissavos, Anatoli, 7.7.2007, 1108 m, 39°45'51.7" N, 22°39'27.8" E, Leg. M. Gogala, T. Trilar.

Description. As already mentioned, we succeeded to collect just one male and one female (Fig. 8). Therefore we can only describe the morphology of single specimens of both sexes. The general habitus of the species resembles the former species and the habitus of other species of the *C. montana* species complex.

The body length from the head to the tip of abdomen is in the male 18.9 mm, while in the female 21 mm. The tegmina in male measure in length 19.3 mm and width 8.3 mm; in the female the length of tegmina is 23.2 mm and the width 9.4 mm.

The overall coloration is black with yellow and reddish-brown markings like in other species of *C. montana* s. lato (Fig. 8).

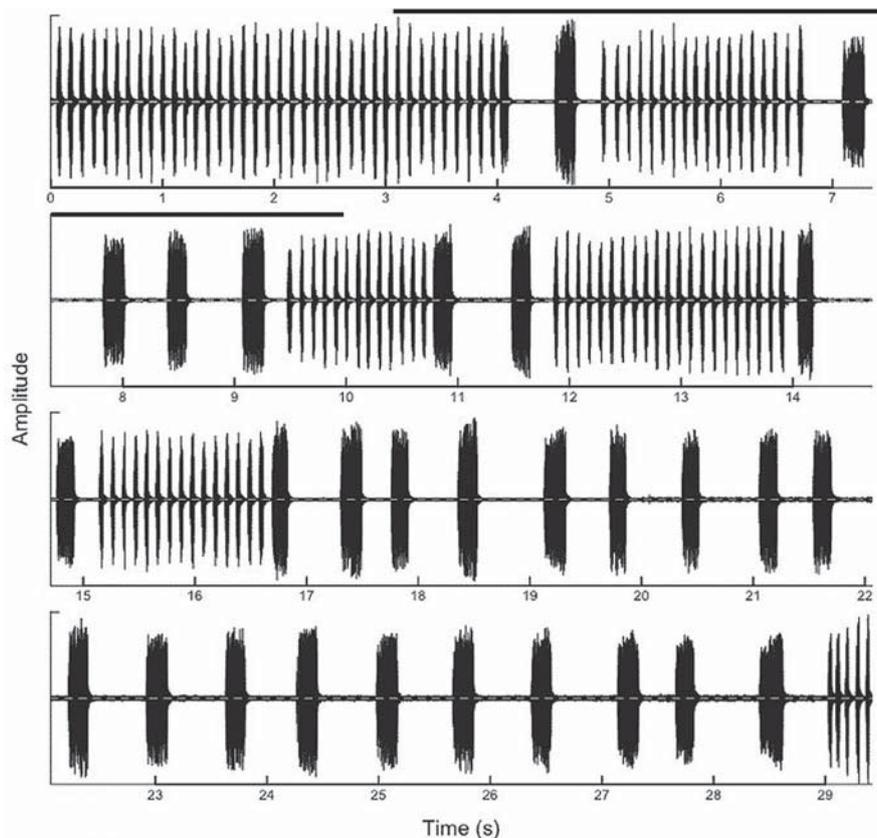


Fig. 5: Oscillogram of the calling song of *Cicadetta kissavi* sp. n. (a typical sequence - black bar above first two rows represents the part of song, shown in Fig. 6). - Software as in Fig. 1.

Male: The head is black, with a yellow patch on the epicranial suture. Postclypeus laterally yellow, rostrum reaching the tip of middle coxae. Pronotum black, front and hind edge with thin yellow or light brown rim laterally. Pronotal collar in the middle with two light yellow-brown patches. Lateral angles of pronotal collar pronounced. Scutum and cruciform elevation black, mesonotal posterior ridge near the wing groove and metanotum basilaterally and posteriorly yellow. Abdominal tergum 1 in front of tymbals with brown markings, tymbal with a tymbal plate, 3 long and 1 short ribs. Terga 3 through 7 black with broad reddish brown borders.

Pygophor (Figs. 9a, c) with triangular dorsal beak and flat, pronounced and rounded upper lobes of pygophor. Basal lobes touching the main capsule (Figs. 9a, c). Median lobe of uncus pronounced, broadly rounded and brown, claspers flat and dark brown, hooked anterolaterad, pseudoparamers slightly flattened, with sharp point. Basal plate of aedeagus broadly Y-shaped (Figs. 9c).

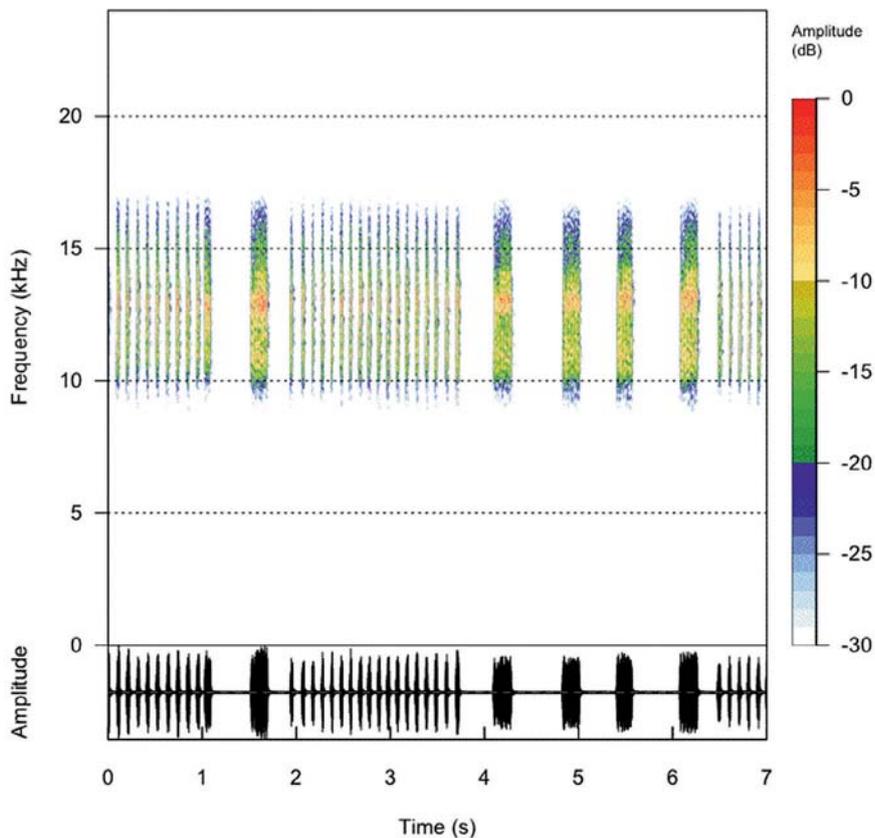


Fig. 6: Spectrogram and oscillogram (below) of the calling song of *Cicadetta kissavi* sp. n. - Software as in Fig. 1.

Ventral side black with yellow to reddish brown markings. Front femora with three spines. Opercula basally dark, distally yellow brown, kidney shaped, not overlapping (Fig. 9d). Meracanthus short, hooked mediad, yellow (Fig. 9d – marked with arrow). Abdominal sternites proximally and medially dark, distal edges broadly yellow brown, episterna proximally dark with yellow brown distal edges. Sternite VIII brown with dark patch in the middle of the proximal part, 2 times longer than the median length of sternite VII (Fig. 9b). Abdominal segments triangular in cross section, dorsally forming a rounded ridge.

Tegmina and hind wings transparent without markings, with exception of clearly coloured basal parts. Ulnar cell 1 slightly longer than apical cell 1 (1.1 time). Basal cells of first wings yellow, frontal edge darker, basal membrane reddish as well as the base of the costal cell of hind wings. Costal vein brown, subcosta light brown. Medial and cubitus anterior and posterior veins till nodal line or even till crossveins yellow. Distal veins on tegmina and on hind wings dark. Veins of hind wings dark

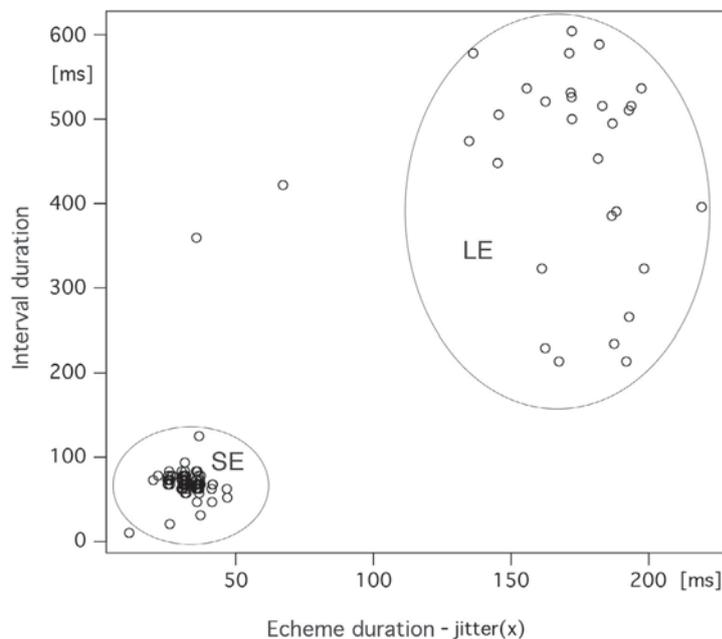


Fig. 7: Scattergram of the short (SE) and long (LE) echeme duration (x) and the following intervals (y) in the calling song of *Cicadetta kissavi* sp. n. - Software as in Fig. 1, a jitter function has been applied to slightly vary the x values in order to show the density of measuring points.

with exception of CuA and CuP veins, which are proximally whitish. Veins of the anal lobe of hind wings with broad reddish brown frame. The number of apical cells on front wings is 8 and on hind wings 6.

Female: Differs from males in the size of the body (see above) and in coloration. Pronotum with two small yellow patches in the median part of the collar as in a male. Ulnar cell 1 of tegmina slightly longer than apical cell 1 (1.2 times). Also tegminal veins M have whitish coloration extended towards apical cells. The form and coloration of female terminalia are shown in Fig. 10a.

Ecology. The individuals were observed sitting and singing mainly on shrubs and smaller coniferous and deciduous trees. We always detected only single singing males. Nevertheless, we were there only for a few hours of one afternoon and therefore our observations cannot be generalized. We acoustically detected and recorded also *C. montana* s. stricto like on Mt. Pilion (Gogala et al. 2008), *Dimissalna dimissa* and *Lyristes plebejus*.

Discussion

We previously reported a wide distribution of *C. hannekeae* in Central and Southern Greece and the presence of *C. macedonica* and *C. montana* s. stricto in

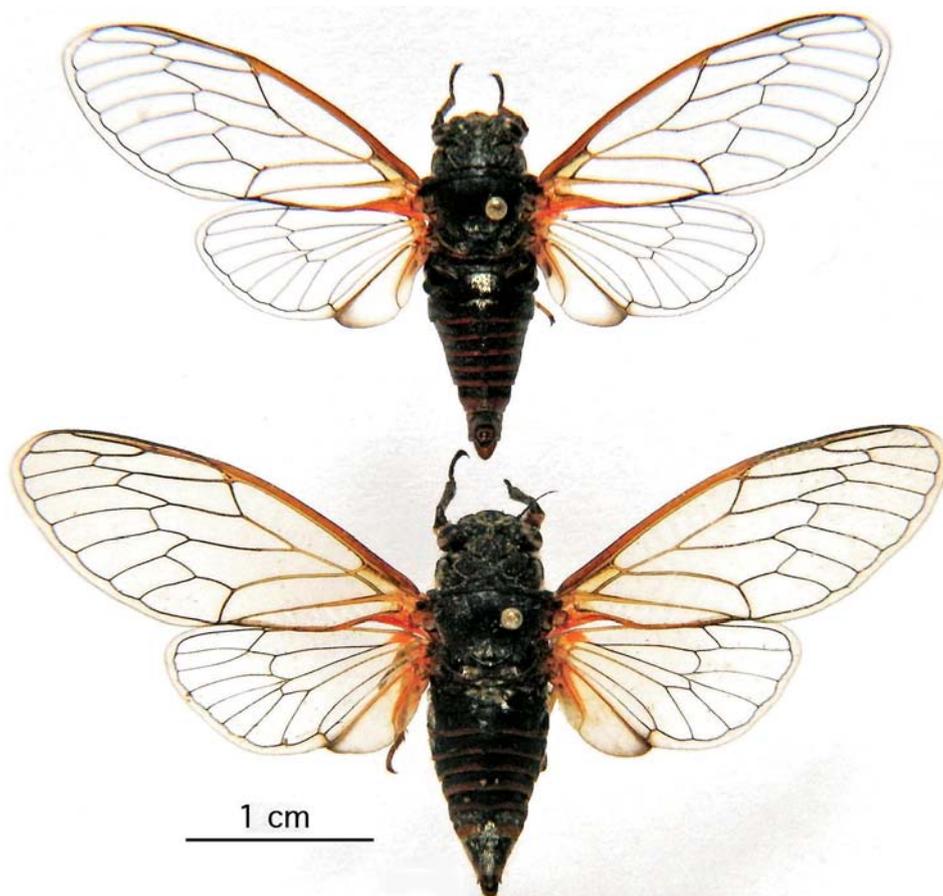


Fig. 8: Habitus of a male (above) and female of *Cicadetta kissavi* sp. n.

Northern Greece (Gogala et al. 2008). Worth mentioning is also the presence of a third species of this complex, *C. cantilatrix* Sueur & Puissant, 2007 in the former Yugoslav Republic of Macedonia (FYROM) close to the Greek border together with the former two (Gogala et al. 2005). In contrast, the eastern part of the Greek mainland near the coast seems to be something special. The closest localities of *C. hannekeae* are on Mt. Othris in the south, and on Mt. Vourinos, about 60 km westwards from Mt. Olymbos (Gogala et al. 2008). *Cicadetta montana* s. stricto has been found on Mt. Pilion (Gogala et al. 2008) and also on Mt. Kissavos, together with the new *C. kissavi*. Thus, both mountains visited by us have their own endemic *Cicadetta* species. The reason for this we should search in the geological events through Pliocene and Pleistocene.

The new species *C. olympica* has a similar song pattern as *C. brevipennis* but strictly without a short echeme at the end of a phrase. They are also morphological-

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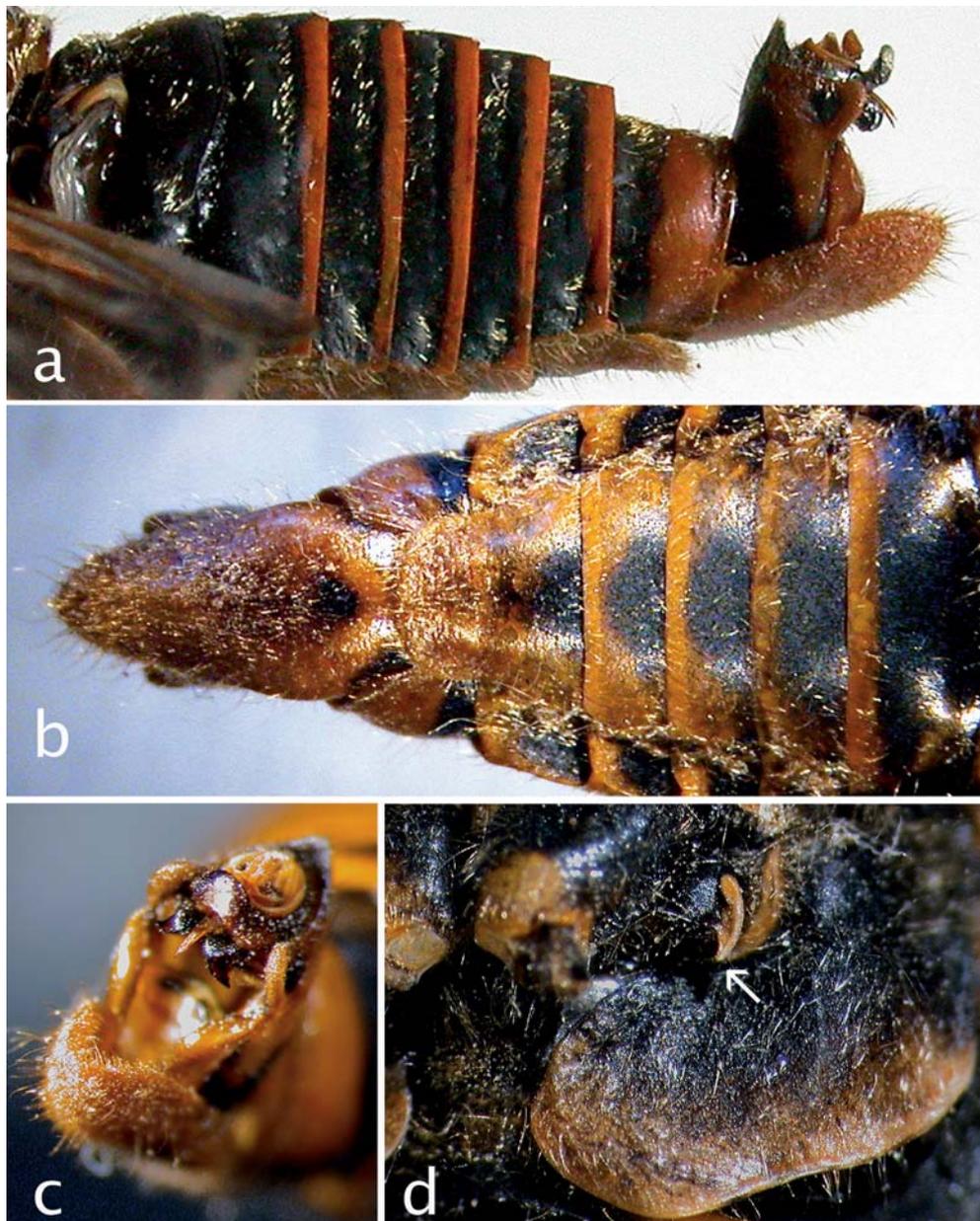


Fig. 9: Morphology of a male of *Cicadetta kissavi* sp. n.: a – lateral view of male abdomen with genitalia; b – ventral view of male abdomen; c – view of male genital capsule from behind, form of uncus, hooked claspers and between them a tip of (retracted) aedeagus and its basis can be seen; d – left operculum with small meracanthus (marked with arrow).

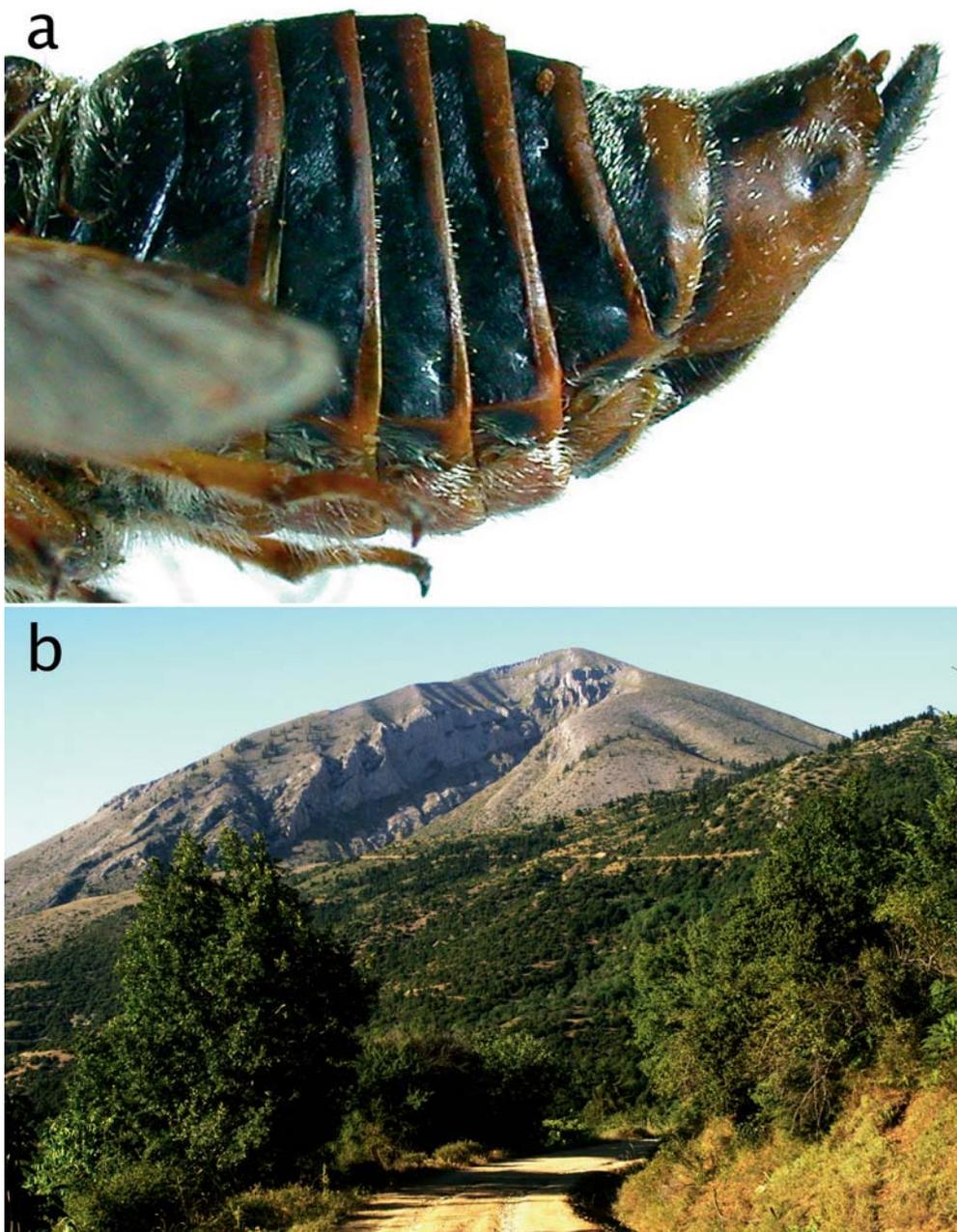


Fig. 10: Morphology and habitat of *Cicadetta kissavi* sp. n.: a – female abdomen with terminalia from the lateral side; b – typical habitat with the peak of Mt. Kissavos in the background.

ly very similar. If both species are really very close related is not yet known, and we are anxiously expecting the results of the molecular analysis of their DNA. A difference to the acoustic pattern of *C. montana* s.str. is in the duration of long echemes, which are in the new species more than ten times shorter (1.6 ± 0.5 s vs. 19.6 ± 7.5 s). For this comparison we only measured *C. montana* recordings from Greece (Pentalofos-Vouria Pindos, Vourinos and Pilion). Values for echeme durations for this species from the Central Europe are even longer, up to 2 minutes! Therefore, there is no overlapping of this parameter in the songs of both species.

The other new species is also morphologically not very different from other species of *C. montana* s. lato and *C. olympica* sp. n. The best morphologic character, also for discrimination between the two new species seems to be the form of the meracanthus (Figs. 3e and 9d – marked with arrow), but to be sure we have to investigate more material. However, the song pattern of *C. kissavi* sp. n. is very different and has more similarities with *C. hannekeae* or *C. macedonica* songs.

It is surprising, that the type localities of both new species are only 45 km away and both species are separated only by the deep and narrow Tembi valley with the river Pinios. However, we have to admit, that we do not have enough detailed data about the geographical distribution of both species yet.

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