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The song structure of *Cicadetta montana macedonica* SCHEDL with remarks on songs of related singing cicadas (Hemiptera: Auchenorrhyncha: Cicadomorpha: Tibicinidae)*

With 4 Figures

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Abstract. The song structure of *Cicadetta montana macedonica* SCHEDL, a new subspecies found in Western Macedonia and described in this issue, is characteristic and easily distinguishable from the songs of other related singing cicadas. The whole phrase can be as short as 0.9 second or longer than 100 seconds but the typical phrase duration is about 6 seconds. The next phrase begins after a half a second long interval. Each phrase consists typically of a many seconds long sequence of short echemes (duration 26 ± 5 ms) repeated about 11 times per second and ending with one long echeme (duration 161 ± 20 ms). The song contains frequencies from 5 to 20 kHz with a maximum between 12 and 14 kHz. This song pattern is compared with songs of other singing cicadas from *C. montana* complex.

Introduction

In July 1997 together with our colleagues from the Macedonian Natural History Museum we visited Galičica mountain between lakes Prespa and Ohrid to acoustically investigate the singing cicadas of this region. During this field trip we heard and recorded a distinct and characteristic song pattern of an unknown cicada species. Specimens were also collected and WOLFGANG SCHEDL described this taxon in the previous paper as *Cicadetta montana macedonica* ssp. n.

In the year 1998 we again recorded songs and collected more specimens in the same region, but also heard or recorded the same dinstinguishable song in other localities of western Macedonia.

In this paper we describe the song of this new taxon and compare it with those of close related singing cicadas.

Materials and methods

Cicadetta montana macedonica SCHEDL has been found mainly in oak forests and clearings on the eastern slopes of Galičica at elevations from 900 to 1600 m (UTM coordinates: DL93, DL83, June 18th till July 5th), around Nove Breznica (EM23, June 30th) and near Osoj at Garska River (DL79, June 19th) (Fig. 1c). Another specimen from Mavrovo (DM71) probably belongs to the same taxon and was found in the collection of the Macedonian Natural History Museum.

* This paper is dedicated to Prof. Dr. REINHARD REMANE, renowned master of hemipterology, at his 70th birthday.

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The songs were detected and recorded by various methods.

For sensitive detection of high pitched sounds we used in this study an ultrasonic microphone mounted on Telinga parabola and connected to a bat detector S-25 Ultra Sound Advice in combination with a DAT tape recorder. This system was described by POPOV et al. (1997).

The standard recordings in the human sonic range were made by using two Telinga microphones, a Telinga stereo Pro 3 microphone and a mono Pro 3 in connection with DAT recorders SONY TCD-D3 and TCD-D10.

Some recordings were also made with a new ultrasonic Telinga Pro 5 Science microphone and a High Speed (HS) DAT recorder Pioneer D-C88 (sampling rate 96 kHz/s) covering the frequency range of 5 to 44000 Hz.

The DAT recordings were transferred to the hard disk of a Power Macintosh G3/233 computer through an Audiomedia III card. Software used for viewing, editing and analyzing the song signals was Digidesign ProTools 4.1 and Canary 1.2.

For statistical evaluation we used the StatView 4.5 program.

The collected specimens are preserved in the Hemiptera collection of the Slovenian Museum of Natural History (PMSL), Ljubljana, Slovenia; in the Macedonian Museum of Natural History, Skopje, Macedonia; and in the collection of WOLFGANG SCHEDL, Innsbruck, Austria.

Results

The habitus of *C. m. macedonica* is shown in Figs. 1a, b. The opercula, translucent tymbal structure with two long ribs and the morphology of the tympanal membranes are presented in Figs. 1d-f.

The song comprises phrases of 0.9 to 19 s (Fig. 3a; in some cases even more than 100 s, see below) duration, and each phrase consists of a fast repetition of many short echemes (SE, repetition frequency approximately 11 ± 1 Hz, Fig. 3d), followed by one long echeme (LE, duration 161 ± 20 ms, Figs. 2, 3e, 4a). The mean duration of short echemes is 26 ± 4.6 ms (Fig. 3b) and the mean interval between them is 63.4 ± 12 ms (Fig. 3c). The last interval preceding the long echeme in a phrase is usually shorter (20 ± 8 ms, Fig. 3f). A new phrase begins after a long echeme and the following pause lasting about half a second (Figs. 2, 4a).

On many occasions very long periods of short echeme repetitions were heard and recorded, lasting over 1 minute, but such long series of short echemes also end with a similar long echeme. The repetition frequency of short echemes in such long phrases is not significantly different when compared to shorter phrases, but the duration of short echemes in such phrases is slightly shorter and the length of intervals longer even in the song of the same animal.

The spectrum of these acoustic signals includes frequencies from about 5 to 20 kHz with a maximum between 12 and 17 kHz (Figs. 2a, b). Songs are not easily detectable by the unaided human ear unless at close distance of up to a few meters. Therefore, we also used a bat detector.

The animals sing during daylight from morning till dusk, in the trees on prominent branches, but also on isolated smaller trees or bushes or even in the grass of forest clearings, where females gather to find mating partners.

All together we evaluated 6 recordings of songs of different animals. The duration of selected sequences for evaluation of SE sequences was 30 to 35 s and for other parameters at least 1 min. All recordings were made at ambient temperatures from 23 to 31 °C.

Fig. 1: Some morphological characteristics of *Cicadetta montana macedonica* SCHEDL, 1999. **a**: specimens from the collection, above female, below male; **b**: live specimen, sitting on stem; **c**: map of western Macedonia with UTM grid and localities marked (big circles: cicadas recorded and collected, small circles: cicadas heard or recorded); **d**: opercula on the ventral side of abdomen; **e**: transparent left tymbal with two long ribs (r); left – anterior side, top – dorsal side; **f**: cross section of the abdomen at the level of tympanal organs, view from behind (left tymbal is punctured); TM – tymbal muscle, Ty – tympanal membrane.

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Fig. 2: *C. m. macedonica* - song. **a:** spectrogram; **b:** sonagram; **c:** oscillogram of the same selection.

Discussion

Despite of small morphological differences (see SCHEDL 1999), the song of *C. m. macedonica* is clearly and easily distinguishable from all other European related species investigated till now (see Fig. 4).

The song of *C. montana* (SCOPOLI, 1772) has been described recently by BOULARD (1995, see also BOULARD & MONDON 1995) as repetition of a few seconds long phrases comprising one long echeme, followed after a short interval by one short echeme (Fig. 4b). The same author reports a similar pattern for the closely related *C. montana petryi* (SCHUMACHER, 1924); the main difference he found in the much longer duration of long echemes (called by BOULARD "phrases", up to more than 1 minute, Fig. 4c). In contrast to this, some other authors described the song of *C. montana* as a long lasting continuous song with irregular interruptions but without any subsequent or repeating short echemes (Fig. 4d). Such songs have even been reported, e.g. for mountain cicadas from Dalmatia (JOERMANN & SCHNEIDER 1987), Russia (POPOV, personal communication) and England (RAGGE & REYNOLDS 1998).

ARTMANN (1987) reported in a short note the occurrence of mountain cicadas with two different song patterns from Switzerland. His simple description of the song he heard in Chilpen reserve is probably closest to the BOULARD's description (1995). ARTMANN named this type of mountain cicada without





a: phrase period duration; b: short echeme (SE) duration; c: interval duration between short echemes;
d: repetition frequency of short echemes;
e: long echeme (LE) duration;
f: duration of the intervals preceding long echemes. In each graph sample sizes, means, and standard deviations are shown.

any differential description as *Cicadetta montana peregrina* – the foreign speaking cicada, and therefore can not be accepted as a valid taxon. In Pfynwald he heard the other song of mountain cicadas with an occasionally interrupted continuous song.

YOUNG JUNE LEE (1998) reported the occurrence of *C. montana* in Korea and described its song, unfortunately without any oscillograms or sonagrams, as comprising one 2 to 3 s long echeme, followed after a 0.1 s short pause by a stronger 1 s long sound of ascending pitch. This pattern is again different but is probably closest to the *C. montana* song described by BOULARD (1995).



Fig. 4: Comparison of song patterns as oscillograms in the same time scale. **a:** *C. m. macedonica* (from the Galičica mountain); **b:** *C. montana* from Lukovica, Slovenia, practically identical to the pattern described by BOULARD (1995); **c:** *C. m. petryi* (sample from the CD companion of BOULARD & MONDON 1995, with author's permission); **d:** *C. montana* from Pletvar, Macedonia with a pattern identical to the songs of mountain cicadas recorded at higher elevations in Slovenia.

In Slovenia, we found both "acoustic forms" of mountain cicadas. Near Ljubljana and Maribor at elevations around 300 m a.s.l. we found, recorded, and collected the specimens singing in accordance to BOULARD's description (1995, Fig. 4b). At higher elevations not far away (Zaplana, Iška, the hills above Hrastnik, 800–1200 m a.s.l.) however, we heard and recorded another continuous type of song without short echemes at the end of a phrase (compare Fig. 4d). Therefore we assume that *Cicadetta montana* (SCOPOLI, 1772) is a complex of morphologically similar, closely related species, distinguishable at the present only by acoustic methods. A major revision of this complex species is needed.

The continuous type of song of *Cicadetta montana* we also heard and recorded (Fig. 4d) during two subsequent years in Macedonia on Pletvar Pass (EL57, 990 m a.s.l.) about 80 km eastwards from Galičica mountain. There, we did not detect *C. m. macedonica* but one can expect that at least in some localities of western Macedonia both taxa are sympatric. Because of this and the fact that the song structure is very different when compared to other taxa of *C. montana* complex, we expect that the *C. m. macedonica* will in future be recognized even as a distinct species.

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