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FAUNA OF SINGING CICADAS (AUCHENORRHYNCHA: CICADOIDEA) OF MACEDONIA – A BIOACOUSTIC SURVEY

Matija GOGALA¹, Tomi TRILAR² and Vladimir T. KRPAČ³

¹ Slovenian Academy of Sciences and Arts,
Novi trg 3, SI-1000 Ljubljana, Slovenia
matija.gogala@guest.arnes.si

² Slovenian Museum of Natural History,
Prešernova 20, SI-1000 Ljubljana, Slovenia
ttrilar@pms-lj.si

³ Macedonian Museum of Natural History,
Bulevar Ilinden 86, 91000 Skopje, Macedonia
vkrpach@seir.net.mk

Abstract – The fauna of singing cicadas (Cicadoidea) of Macedonia has been investigated with classic and bioacoustic methods, using recording equipment for sonic range and ultrasonic detectors. In the literature we found data for 6 species, but the reported locality of *Tibicina steveni* (Krynicky, 1837) is in Bulgaria. In addition to the remaining 5 species: *Lyristes plebejus* (Scopoli, 1763), *Cicada orni* Linné, 1758, *Tibicina haematodes* (Scopoli, 1763), *Cicadatra atra* (Olivier, 1790) and *C. hyalina* (Fabricius, 1798), we discovered in Macedonia 10 more species: *Cicadatra platyptera* Fieber, 1876, *C. persica* Kirkaldy, 1909, *Tettigetta brullei* (Fieber, 1876), *T. dimissa* (Hagen, 1856), *Cicadetta montana* (Scopoli, 1772), *C. cerdaniensis* Puissant & Boulard, 2000, *C. macedonica* Schedl, 1999, *C. cf. podolica* (Eichwald, 1830), *C. tibialis* (Panzer, 1798) and *Pagiphora annulata* (Brullé, 1832). The distribution of species is shown in maps with UTM grid. Additional new bioacoustic data for *Cicadatra platyptera* and *P. annulata* are included.

KEY WORDS: Macedonia, singing cicadas, Cicadoidea, fauna, bioacoustics

Izveček FAVNA ŠKRŽADOV MAKEDONIJE (AUCHENORRHYNCHA: CICADOIDEA) – RAZISKAVA Z BIOAKUSTIČNO METODO

Favno škržadov Makedonije smo raziskovali s klasičnimi in bioakustičnimi metodami. Uporabljali smo naprave za snemanje v nam slišnem območju in

ultrazvočne detektorje. V literaturi smo našli podatke za 6 vrst, vendar je navedeno najdišče za vrsto *Tibicina steveni* (Krynicky, 1837) v Bolgariji. Ostalih pet vrst: *Lyrister plebejus* (Scopoli, 1763), *Cicada orni* Linné, 1758, *Tibicina haematodes* (Scopoli, 1763), *Cicadatra atra* (Olivier, 1790) in *C. hyalina* (Fabricius, 1798) smo dopolnili z desetimi novo odkritimi vrstami: *Cicadatra platyptera* Fieber, 1876, *C. persica* Kirkaldy, 1909, *Tettigetta brullei* (Fieber, 1876), *T. dimissa* (Hagen, 1856), *Cicadetta montana* (Scopoli, 1772), *C. cerdaniensis* Puissant & Boulard, 2000, *C. macedonica* Schedl, 1999, *C. cf. podolica* (Eichwald, 1830), *C. tibialis* (Panzer, 1798) in *Pagiphora annulata* (Brullé, 1832). Razširjenost v Makedoniji je prikazana na zemljevidih z mrežo UTM. Za vrsti *C. platyptera* in *P. annulata* so navedeni novi bioakustični podatki.

KLJUČNE BESEDE: Makedonija, škržadi, Cicadoidea, favna, bioakustika

Introduction

The fauna of singing cicadas of Macedonia has not been thoroughly investigated in the past. Some material, present in the collections of the Macedonian Museum of Natural History has been collected by various authors, mainly during and after World War II. Some foreign entomologists also collected material during various excursions or visits to this part of the Balkans and this material is scattered in various european collections. JANKOVIĆ (1971) and JANKOVIĆ & PAPOVIĆ (1981) listed only 6 species of singing cicadas for Macedonia: *Lyrister plebejus* (Scopoli, 1763), *Cicada orni* Linné, 1758, *Tibicina haematodes* (Scopoli, 1763), *T. steveni* (Krynicky, 1837), *Cicadatra atra* (Olivier, 1790) and *C. hyalina* (Fabricius, 1798), most of which were collected occasionally.

Material and Methods

Since 1996 we investigated the singing cicadas (Auchenorrhyncha: Cicadoidea) of Macedonia by using classical and bioacoustic methods. We recorded the songs of cicadas with acoustic equipment including microphones, sensitive in sonic (Telinga Pro 3 mono, 3 stereo, 5 stereo, Science) and ultrasonic range (Pettersson), DAT-recorders (Sony TCD-D3, TCD-D7, TCD-D10, Pioneer 77) and ultrasonic detectors (Ultra Sound Advice 25, Pettersson D-200). Computer programs used for the analysis of acoustic data are Canary 1.4, Digidesign ProTools IV and similar programs (for detailed description see POPOV et al., 1997: Material and Methods). These methods enabled us to get much more representative data about the presence and distribution of Cicadoidea in this country.

Collected specimens are preserved in the collections of the Slovenian Museum of Natural History (PMSL) in Ljubljana and the Macedonian Museum of Natural History (SKO) in Skopje. We consider in this paper also data from material, deposited in the Zoological Museum of Amsterdam, Faculty of Natural Sciences,

University of Amsterdam (ZMAN). Faunistic data, produced during our joint research in the years 1996 till now and preserved in the PMSL collection, are marked in the lists as GTK (M. Gogala, T. Trilar, V. Krpač, PMSL). For all localities the UTM coordinates in 10 x 10 km grid are given. The data for each species are sorted according to UTM coordinates. Following abbreviations are used: C = collection, R = acoustic recording, H = songs were heard but not recorded and Ent.Exc. ZMAN = Entomological Excursion by the Zoological Museum in Amsterdam. All sound recordings are stored in the Sound archive of the Slovenian Museum of Natural History in Ljubljana. Selected samples are available also on the web pages "Songs of the European singing cicadas":

<http://www2.pms-lj.si/european-cicadas/>

Results

All together 16 species or subspecies of singing cicadas were discovered. In addition to the six taxa mentioned by JANKOVIĆ (1971) and JANKOVIĆ & PAPOVIĆ (1981) also *Cicadatra platyptera* Fieber, 1876, *C. persica* Kirkaldy, 1909, *Tettigetta brullei* (Fieber, 1876), *T. dimissa* (Hagen, 1856), *Cicadetta montana* (Scopoli, 1772), *C. cerdaniensis* Puissant & Boulard, 2000, *C. macedonica* Schedl, 1999, *C. cf. podolica* (Eichwald, 1830), *Cicadetta tibialis* (Panzer, 1798) and *Pagiphora annulata* (Brullé, 1832). Songs of all taxa mentioned above were recorded, with exception of *T. steveni*, which is listed in JANKOVIĆ (1971), but this record actually refers to Bulgaria. We did not collect nor record this cicada in Macedonia. *Tettigetta brullei* has not been collected but clearly acoustically detected. A few specimens of *C. montana* s. str. were either collected in some localities without previous acoustic recordings or only detected and recorded in other localities.

The three ubiquitous, loudest and largest singing cicadas *L. plebejus*, *C. orni* and *T. haematodes* were acoustically detected and also collected in many localities in Macedonia. Some other species were not so easily discovered and localized acoustically and especially for the *C. montana* group of sister species the ultrasound detectors were needed to confirm their presence. Faunistic data for single species are presented below.

CICADIDAE

Lyristes plebejus (Scopoli, 1763)

The largest species of singing cicadas in Macedonia is *L. plebejus*. Its song has been described by POPOV (1969, 1975), BOULARD (1995), GOGALA (2002) and others. Map with data on geographic distribution in Macedonia is shown in Fig. 1.

DL83: Ohrid, Peštani, Gradište, 700 m, 4. 7. 1998, R, C (GTK); Ohrid: Gradište, 4. 7. 1998, C (V. Krpač, SKO);

EL58: Mukos, 12 km NO of Prilep, 24. 7. 1965, C (Ent.Exc. ZMAN);

EL59: Izvor, 17 km ZZW of Veles, 22. 7. 1965, C (Ent.Exc. ZMAN);

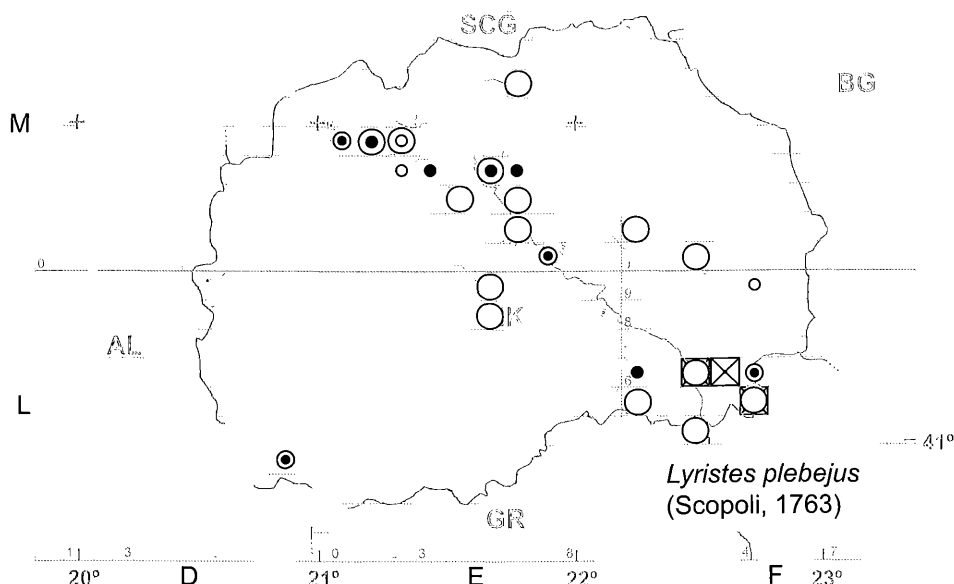


Fig. 1: Distribution of *Lyristes plebejus* in Macedonia using 10 x 10 km UTM grid. Explanation of symbols is shown in the caption of Fig. 2.

- EM04:** Tetovo: Cerovo, 30. 6. 1998, C (V. Krpač, SKO); Tetovo: Cerovo, 30. 6. 2000, C (M. Ivanov, SKO); Tetovo: Cerovo, 3. 7. 2000, C (M. Ivanov, SKO); Cerovo, Mt. Žeden, 30. 6. 1998, R, C (GTK); 28. 6. 2000, R (GTK);
- EM14:** Mt. Žeden, 2. 7. 1976, C (J. Čingovski, SKO); Skopje, 20 km W, 30. 6. 1975, C (J.P. Duffels, ZMAN); Skopje, Laskarci, 30. 6. 1998, R (GTK);
- EM23:** Skopje, Suva Planina, Nova Breznica, 30. 6. 1998, H (GTK);
- EM24:** Skopje: Treska river, 15. 7. 1941, C (G. Stojanov, SKO); Skopje, Matka, 6. 7. 1998, H (GTK);
- EM33:** Mt. Kitka, 1000 m, 7. 7. 1996, R (GTK);
- EM42:** Skopje, 20 km S, 2. 8. 1967, C (F. & L. Willemse & J. Tilmans, ZMAN);
- EM53:** Skopje: Katlanovo, 18. 7. 1959, C (D. Simova, SKO); Katlanovo, 5. 7. 1996, R (GTK);
- EM61:** Veles: Cerovo, 13. 7. 1970, C (J. Čingovski, SKO); Veles: Cerovo, 19. 7. 1967, C (J. Čingovski, SKO); Veles, 15. 7. 1975, C (J. Čingovski, SKO); Cerovo, 10 km N of Veles, 28. 7. 1965, C (Ent.Exc. ZMAN);
- EM62:** Veles, 7 km NE, 13. 7. 1969, C (F. Willemse, ZMAN); Veles, 7 km NO, 25. 7. 1965, C (Ent.Exc. ZMAN);
- EM63:** near Breznica, 5. 7. 1996, R (GK);
- EM66:** Kumanovo: Tromeda, 27. 7. 1963, C (J. Čingovski, SKO);
- EM70:** Ulanci, Solena Dolina, 5.-7. 7. 1998, R, C (GTK);

FL05: Mt. Kožuf, 13. 7. 1963, C (J. Čingovski, SKO);
FL06: Staro Konsko, 520 m, 6. 7. 1996, R (GTK);
FL24: Gevgelija, 11. 7. 1963, C (J. Čingovski, SKO); Gevgelija, 11. 7. 1969, C (J. Čingovski, SKO);
FL26: Miletkovo (JANKOVIĆ, 1971);
FL36: Valandovo, 29. 7. 1989, C (Trajče, SKO); Valandovo (JANKOVIĆ, 1971);
FL45: Dojran, 19. 7. 1957, C (J. Čingovski, SKO); Dojran, 29. 6. 1994, C (V. Krpač, SKO); Dojran, 30. 6. 1994, C (V. Krpač, SKO); Dojran, 1. 7. 1994, C (V. Krpač, SKO); Star Dojran, 5. 7. 1996, R (GTK); Dojran (JANKOVIĆ, 1971);
FL46: Dojran: Ačikot, 5. 7. 1996, C (V. Krpač, SKO); Dojran, Ačikot, 5. 7. 1996, R, C (GTK);
FL49: Strumica, Hamzali, 305 m, 2. 7. 1998, H (GTK);
FM01: Štip, 23. 7. 1965, C (Ent.Exc. ZMAN);
FM20: Radoviš, 6. 7. 1973, C (J. Čingovski, SKO).

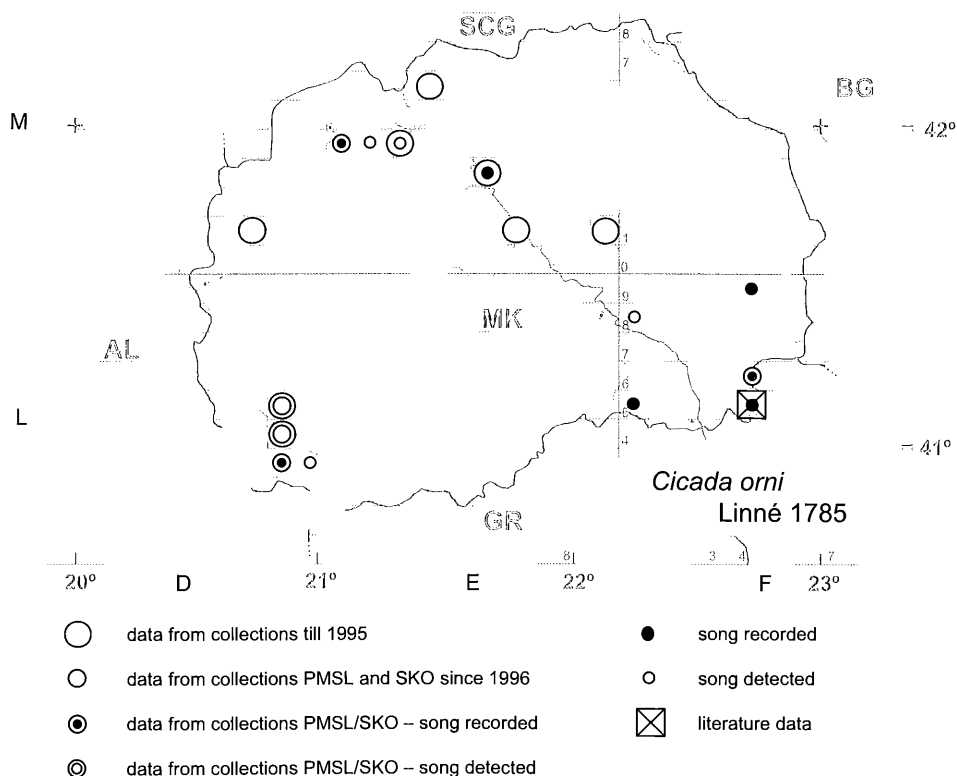


Fig. 2: Distribution of *Cicada orni* in Macedonia. Explanation of symbols for all distribution maps with UTM grid 10 x 10 km is shown.

***Cicada orni* Linné, 1758**

This is the most abundant and common species of singing cicadas found in Macedonia. The song has been described by many authors, e.g. POPOV (1969, 1975), BOULARD (1995) or PINTO-JUMA et al. (2005). Map with data on geographic distribution in Macedonia is shown in Fig. 2.

DL83: Ohrid, Peštani, Gradište, 700 m, 4. 7. 1998, R, C (GTK); Mt. Galičica, cableway, 1400 m, 5. 7. 1998, H (GTK); Ohrid: Gradište, 4. 7. 1998, C (V Krpač, SKO);

DL84: Ohrid, 6. 1968, C (O. Popovska, SKO); Ohrid: Lagadin, 7. 1997, C (O. Popovska, SKO);

DL85: Ohrid, 600 m, 6.-14. 7. 1977, C (J.G. Schulten, ZMAN); 2.-16. 7. 1997, C (H.A. & O. Coene, ZMAN);

DL93: Mt. Galičica, Leskoec, 1050 m, 3.-5. 7. 1998, H (GTK);

DM71: Mavrovo, 2. 7. 1975, C (J. Čingovski, SKO);

EM04: Tetovo: Cerovo, 30. 6. 1998, C (V Krpač, SKO); Tetovo: Cerovo, 30. 6. 2000, C (M. Ivanov, SKO); Tetovo: Cerovo, 3. 7. 2000, C (M. Ivanov, SKO); Cerovo, Mt. Žeden, 28. 6. 2000, R; 30. 6. 1998, R; 6. 7. 1998, R (GTK);

EM14: Skopje, Laskarci, 30. 6. 1998, H (GTK);

EM24: Skopje, Matka, 6. 7. 1998, H (GTK); Skopje: Treska, 15. 7. 1941, C (K. Tuleškov, SKO); Skopje: Matka, 16. 7. 1943, C (K. Tuleškov, SKO); Skopje: Matka, 16. 7. 1943, C (K. Bogoevski, SKO); Skopje: Matka, 16. 7. 1943, C (G. Stojanov, SKO);

EM36: Skopje, Banjani, 21. 6. 1950, C (K. Bogoevski, SKO);

EM53: Skopje: railway station Pčinja, 28. 6. 1951, C (K. Bogoevski, SKO); Kožle, Pčinja, 1. 7. 1998, H (GTK); Katlanovo, 5. 7. 1996, R (GTK);

EM61: Veles, 15. 7. 1975, C (J. Čingovski, SKO);

EM91: Štip, 23. 7. 1965, C (Ent.Exc. ZMAN);

FL05: Staro Konsko, 520 m, 6. 7. 1996, R (GTK);

FL08: Demir Kapija, 1. 7. 1998, H (GTK);

FL45: Star Dojran, 5. 7. 1996, R (GTK); Dojran, 1. 7. 1969 (JANKOVIĆ, 1971);

FL46: Dojran: Ačikot, 5. 7. 1996, C (V Krpač, SKO); Dojran, Ačikot, 5. 7. 1996, R, C (GTK);

FL49: Strumica, Hamzali, 305 m, 2. 7. 1998, H (GTK); Strumica, Hamzali, 390 m, 2. 7. 1998, R (GTK).

***Cicadattra atra* (Olivier, 1790)**

This species is abundant everywhere in Macedonia. The song and acoustic behaviour has been described by BOULARD (1992b). During our field work in Macedonia we studied the wing clicking mechanism (GOGALA & TRILAR 2003). Map with data on geographic distribution in Macedonia is shown in Fig. 3.

DL83: Ohrid: Gradište, 4. 7. 1998, C (V Krpač, SKO); Mt. Galičica: Prespa side, 5. 7. 1998, C (V Krpač, SKO); Ohrid, Peštani, Gradište, 700 m, 4. 7. 1998, R, C (GTK);

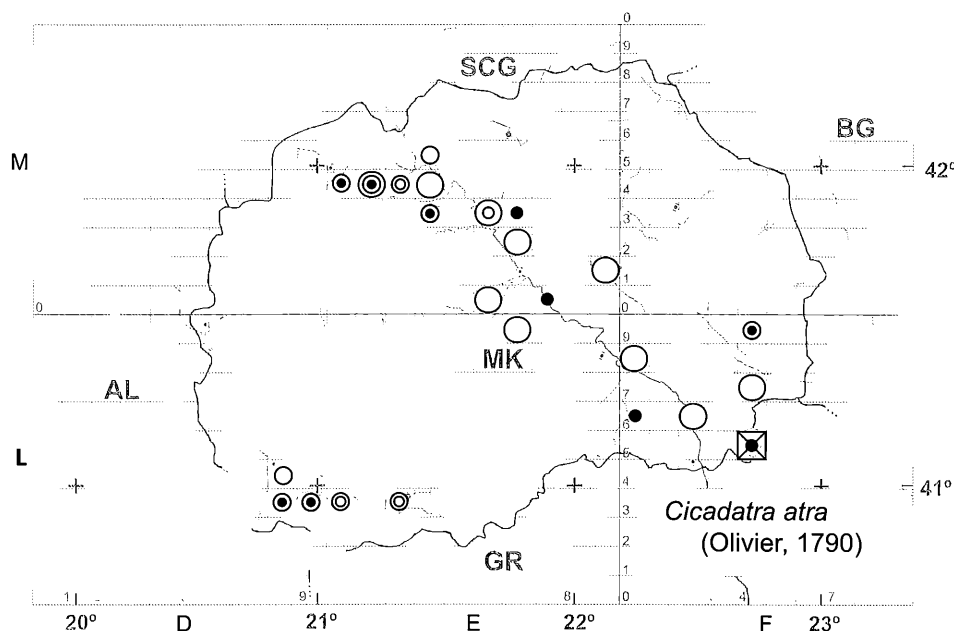


Fig. 3: Distribution of *Cicadatra atra* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

- DL84:** Ohrid, 600 m, 2.-16. 7. 1997, C (H.A. & O. Coene, ZMAN);
DL93: Mt. Galičica, Leskoec, 1050 m, 3.-5. 7. 1998, R, C (GTK);
EL03: Prespa lake: Pretor, 3. 7. 1998, C (V Krpač, SKO); Resen, Pretor, 850 m, 3. 7. 1998, H, C (GTK);
EL23: Pelister: Dihovo, 3. 7. 1998, C (V Krpač, SKO); Pelister, Dihovo, 880 m, 3. 7. 1998, H, C (GTK);
EL69: Prilep, 30 km NE, 1. 7. 1975, C (J.P. Duffels, ZMAN);
EM04: Tetovo: Cerovo, 30. 6. 1998, C (V Krpač, SKO); Cerovo, Mt. Žeden, 30. 6. 1998, R, C; 28. 6. 2000, R (GTK);
EM14: Skopje, 20 km W, 30. 6. 1975, C (J.P. Duffels, ZMAN); Skopje, Laskarci, 30. 6. 1998, R, C; 27. 6. 2000, R (GTK);
EM24: Skopje, Arnakija, 30. 6. 1998, H, C (GTK);
EM33: Crvena voda, 7. 7. 1996, R, C (GTK);
EM34: Skopje: Vodno, 5. 7. 1942, C (K. Bogoevski, SKO);
EM35: Skopje: road to Tetovo, 30. 6. 1998, C (V Krpač, SKO);
EM50: Izvor, 17 km SSW of Veles, 22. 7. 1965, C (Ent.Exc. ZMAN); Izvor, 3 km W (Babuna), 400 m, 13. 7. 1969, C (F. Willemse, ZMAN); Izvor, 7 km E (Babuna) 400 m, 13. 7. 1969, C (F. Willemse, ZMAN);

EM53: Skopje: Railway station Pčinja, 7. 7. 1942, C (K. Tuleškov, SKO); Skopje: Railway station Pčinja, 7. 7. 1942, C (K. Bogoevski, SKO); Kožle, Pčinja, 1. 7. 1998, H (GTK);

EM62: Veles: Otovica, 19. 7. 1967, C (N. Topukova, SKO);

EM63: near Breznica, 5. 7. 1996, R (GTK);

EM70: Ulanci, Solena Dolina, 7. 7. 1998, R (GTK); Ulanci, near the Vardar river, 16. 6. 1997, R (GTK);

EM91: Štip, 23. 7. 1965, C (Ent.Exc. ZMAN);

FL06: Staro Konsko, 6. 7. 1996, R (GTK);

FL08: Demir Kapija, 30. 6. 1975, C (M.J. & J.P. Duffels, ZMAN);

FL26: Negorci (Gevgelija); 1. 7. 1974, C (F. Willemse, ZMAN);

FL45: Star Dojran, 5. 7. 1996, R (GTK);

FL47: Strumica: Kolečino, 6. 6. 1986, C (B. Mihajlova, SKO);

FL49: Strumica: Hamzali, 2. 7. 1998, C (V Krpač, SKO); Strumica, Hamzali, 390 m, 2. 7. 1998, R, C (GTK).

Cicadatra hyalina (Fabricius, 1798)

Cicadatra hyalina, which is somewhat smaller than *C. atra*, is quite common in many hot and dry open grassy areas. The song has been described by BOULARD (1995). Map with data on geographic distribution in Macedonia is shown in Fig. 4.

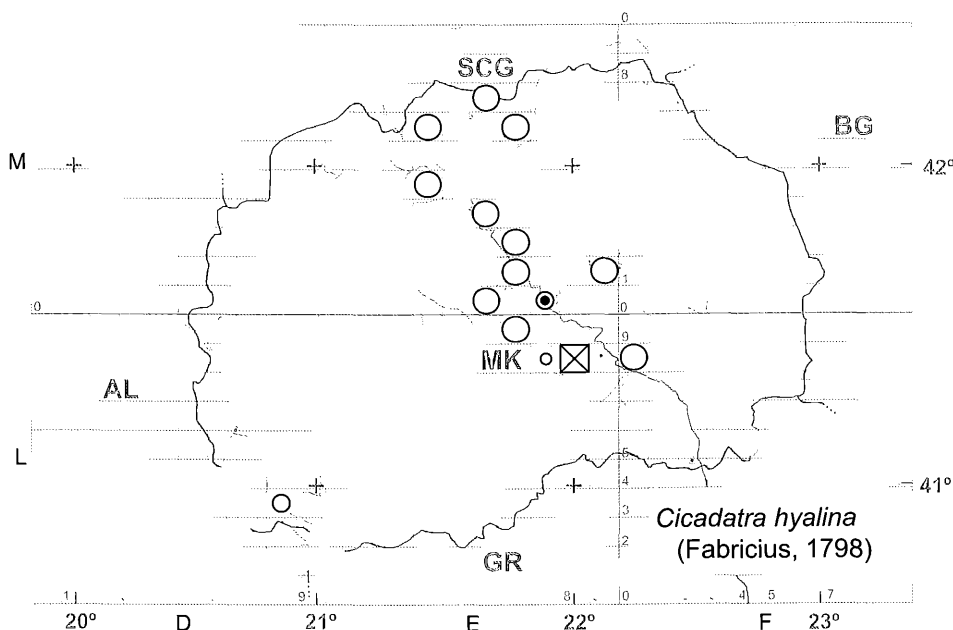


Fig. 4: Distribution of *Cicadatra hyalina* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

DL83: Ohrid: Gradište, 4. 7. 1998, C (V Krpač, SKO);
EL69: Prilep, 30 km NE, 1. 7. 1975, C (ZMAN);
EL78: Drenovo, 17. 6. 1997, H (GTK);
EL88: Kavadarci, 3. 7. 1975 (JANKOVIĆ & PAPOVIĆ 1981);
EM34: Skopje: Vodno, 5. 7. 1942, C (K. Bogoevski, SKO); Skopje: Vodno, 17. 7. 19?? C (SKO);
EM36: Skopje, 15 km N, 28. 6. 1973, C (ZMAN);
EM50: Izvor, 17 km SSW from Veles, 22. 7. 1965, C (Ent.Exc. ZMAN);
EM53: Kožle, Pčinja, 27. 6. 1951, C (S. Joksimović, SKO);
EM57: Kumanovo, 10 km N, 29. 6. 1975, C (J.P. Duffels, ZMAN);
EM61: Veles, 23. 7. 1965, C (Blommers, ZMAN); Veles, 15. 7. 1975, C (J. Čingovski, SKO);
EM62: Veles, 7 km NO, 20. 7. 1965, C (Ent.Exc. ZMAN); Veles, 7 km NE, 250 m, 2. 8. 1966, C, 13. 7. 1969, C (F.Willemse, ZMAN); Veles, Mladost lake, 17. 7. 1971, C (F. Willemse, ZMAN); Otovica, 10 km N from Veles, 28. 7. 1965, C (Ent.Exc. ZMAN); Veles: Otovica, 19. 7. 1967, C (J. Čingovski, SKO);
EM66: Kumanovska banja, 20.-21. 7. 1965, C (Ent.Exc. ZMAN);

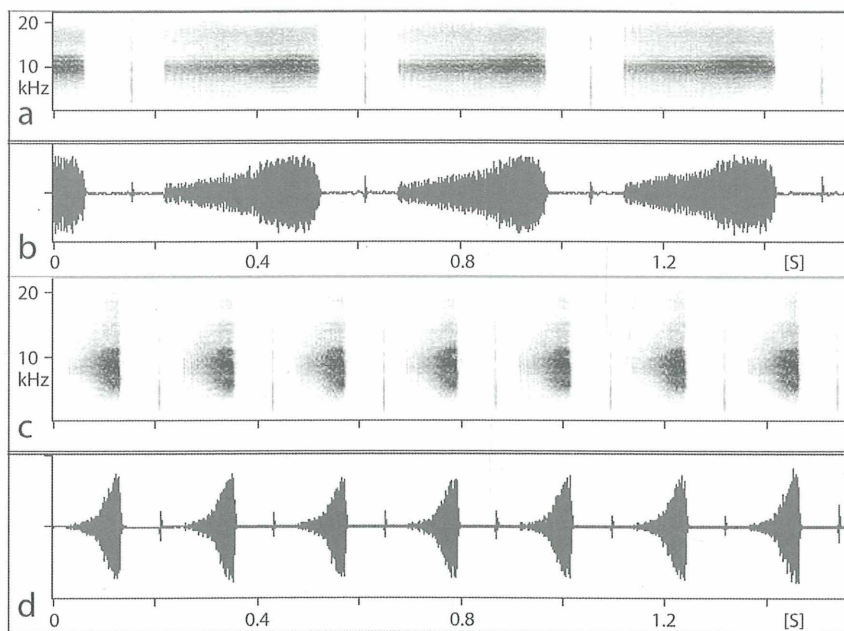


Fig. 5: A comparison of clicking (courtship) song of two *Cicadatra* males. a, b – *Cicadatra atra*; c, d – *Cicadatra platyptera*. Spectrograms (a, c) and oscillograms (b, d) are shown. In both species wing clicks follow short tymbal echemes but the repetition rate is about two times higher in *Cicadatra platyptera*.

EM70: Ubogo, Bregalnica, 15. 6. 1997, R, C (GTK); Ulanci, Solena Dolina, 16. 6. 1997, R, C; 5.-7. 7. 1998, R, C (GTK); Negotino: Solena Dolina, 16. 6. 1997, C; 5. 7. 1998, C; 7. 7. 1998, C (V Krpač, SKO);
EM91: Štip, 23. 7. 1965, C (Ent.Exc. ZMAN);
FL08: Demir Kapija, 30. 6. 1975, C (M.J. & J.P. Duffels, ZMAN).

Cicadatra platyptera Fieber, 1876

It has similar song pattern as the closely related *C. atra* (see also BOULARD 1995), but the repetition rate of a calling and courtship songs of *C. platyptera* is almost twice as high and therefore clearly different from the songs of *C. atra*. BOULARD (1995) described the calling song of *C. platyptera* but did not show a courtship song with wing clicks nor the rivalry song or distress call, which we observed and recorded. We never heard a continuous song in *C. platyptera* in contrast with other sympatric species of *Cicadatra* and also BOULARD (1995) does not mention it. The similar courtship songs of *C. platyptera* and *C. atra* are presented in Fig. 5.

Cicadatra platyptera we found only in the arid region of Solena Dolina or Slandol near Negotino, together with *C. atra* and *C. hyalina* (see data below). Map with data on geographic distribution of *C. platyptera* in Macedonia is shown in Fig. 6.

EM70: Ulanci, Solena Dolina, 16. 6. 1997, R, C; 5.-7. 7. 1998, R, C (GTK); Negotino: Solena Dolina, 16. 6. 1997, C; 7. 7. 1998, C (V. Krpač, SKO).

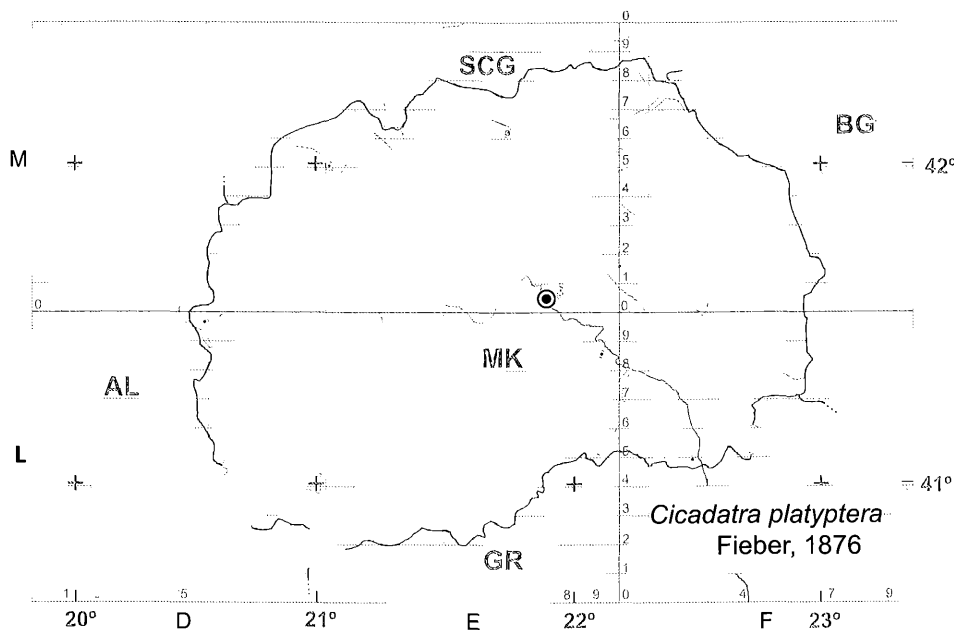


Fig. 6: Distribution of *Cicadatra platyptera* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

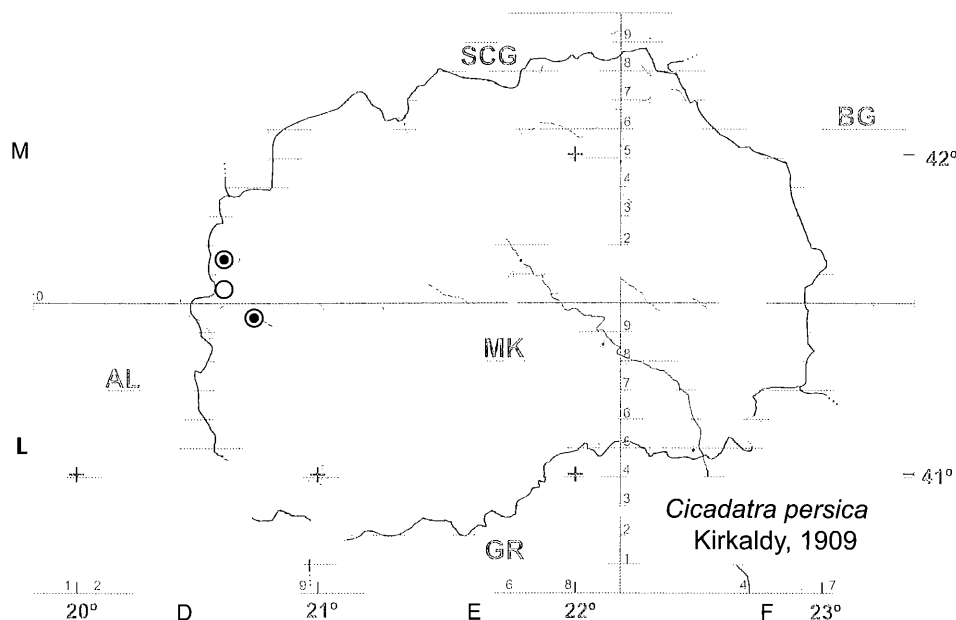


Fig. 7: Distribution of *Cicadatra persica* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

Cicadatra persica Kirkaldy, 1909

The discovery of this cicada species in Macedonia was a big surprise. We found it on the slopes of the Radika gorge and in the Garska valley (GOGALA & TRILAR 1998, 2003). The song with intensive wing clicking has been described for the first time by GOGALA & TRILAR (1998). Some years later GOGALA & TRILAR (2003) described the wing clicking mechanism. Map with data on geographic distribution in Macedonia is shown in Fig. 7.

DL79: Osoj, near Elenski skok, 19. 6. 1997, R, C; 10. 7. 1996, R (GTK);

DM60: Radika: Rostuše, 19. 6. 1997, C (V. Krpač, SKO);

DM61: Radika, Vrbjani, 19. 6. 1997, R, C (GTK).

TIBICINIDAE

Tibicina haematodes (Scopoli, 1763)

This colourful cicada species has been found in many localities in Macedonia. The song recorded during our field work does not differ from the pattern recorded and analyzed in “terra typica” (Slovenia) or described by BOULARD (1995) and SUEUR & AUBIN (2002). Map with data on geographic distribution in Macedonia is shown in Fig. 8.

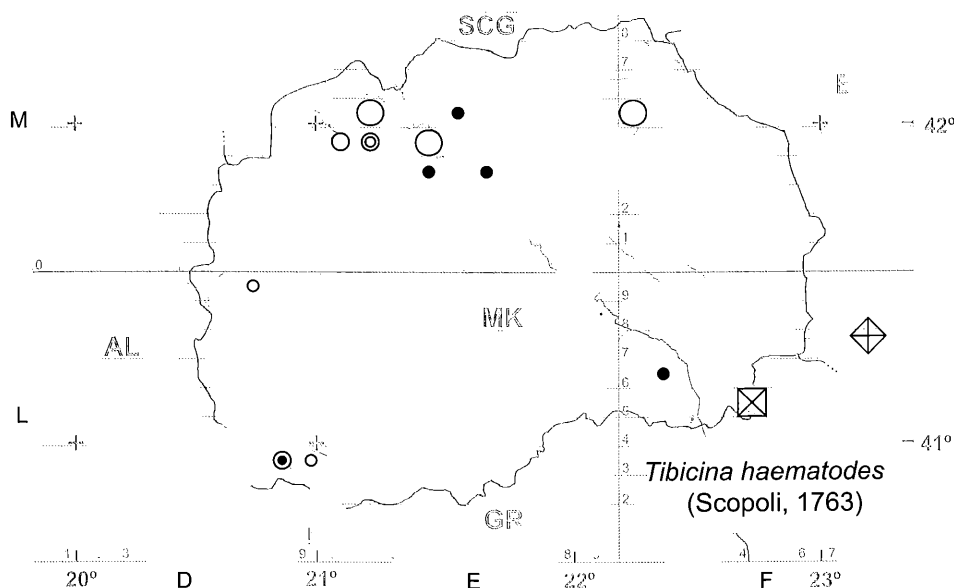


Fig. 8: Distribution of *Tibicina haematodes* in Macedonia and the locality Petrič in Bulgaria, from where *Tibicina steveni* has been reported (rotated symbol at the lower right part of the map). Explanation of other symbols is shown in the caption of Fig. 2.

DL79: Osoj, near Elenski skok, 19. 6. 1997, H (GTK);

DL83: Ohrid: Gradište, 4. 7. 1998, C (V Krpač, SKO); Mt. Galičica, 24. 6. 2003, C (M. Ivanov, SKO); Ohrid, Peštani, Gradište, 700 m, 4. 7. 1998, R, C (GTK); Mt. Galičica, 1000 m, 18. 6. 1997, H (GTK); Ohrid, Trpejica, 750 m, 18. 6. 1997, H (GTK);

DL93: Mt. Galičica, Leskoec, 1050 m, 18. 6. 1997, H (GTK);

EM04: Tetovo: Cerovo, 30. 6. 2000, C (M. Ivanov, SKO); Tetovo: Cerovo, 3. 7. 2000, C (M. Ivanov, SKO); Cerovo, Mt. Žeden, 30. 6. 1998, C (GTK);

EM14: Skopje: Laskarci, 30. 6. 1998, C (V Krpač, SKO); Skopje, Laskarci, 30. 6. 1998, H, C (GTK);

EM15: Mt. Žeden, 2. 7. 1976, C (J. Čingovski, SKO);

EM33: Kitka, 1000 m, 7. 7. 1996, R (GTK);

EM34: Skopje: Vodno, 5. 7. 1942, C (K. Bogoevski, SKO);

EM45: Aračinovo, 14. 6. 1997, R (GTK);

EM53: Katlanovo, 5. 7. 1996, R (GTK);

FL16: Staro Konsko, 520 m, 6. 7. 1996, R (GTK);

FM05: Kratovo, 22. 6. 1963, C (J. Čingovski, SKO).

Tibicina steveni (Krynicky, 1837)

This species is reported for Macedonia by JANKOVIĆ (1971). However, the locality mentioned by him, Petrič, is a town in the Strumica valley in SW Bulgaria, not far from the Macedonian border. We could not confirm the presence of *T. steveni* in Macedonia, but according to the new data on the distribution of this species in Europe (SUEUR et al. 2003) and the vicinity of the locality Petrič it would not be surprising to find it in Macedonia as well.

Cicadetta tibialis (Panzer, 1798)

This small cicada is widely spread and abundant in Macedonia. The species was placed by BOULARD (1982) in a separate genus *Cicadivetta*. The song has been described by BOULARD (1995) and in more details by GOGALA et al. (1996). Map with data on geographic distribution in Macedonia is shown in Fig. 9.

DL83: Ohrid: Gradište, 4. 7. 1998, C (V Krpač, SKO); Mt. Galičica, Leskoec, 1050 m, 18. 6. 1997, R; 3.-5. 7. 1998, R, C (GTK); Mt. Galičica: Leskoec, 5. 7. 1998, C (V. Krpač, SKO); Ohrid, Peštani, Gradište, 700 m, 4. 7. 1998, R, C (GTK); Ohrid, Trpejica, 750m, 18. 6. 1997, H (GTK);
EL67: Prilep, Trojaci, 17. 6. 1997, R, C (GTK); Prilep, Trojaci, 17. 6. 1997, C (V Krpač, SKO);

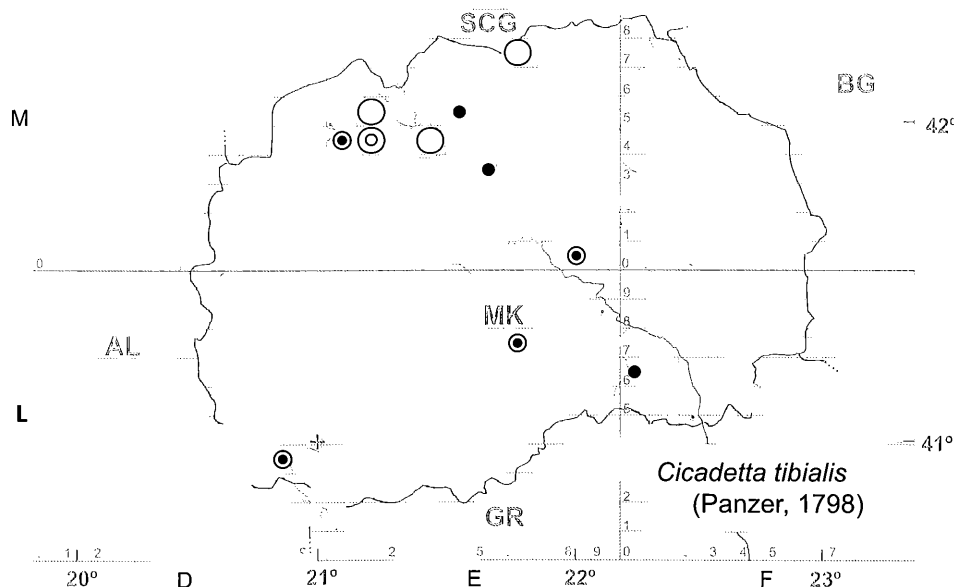


Fig. 9: Distribution of *Cicadetta tibialis* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

- EM04:** Cerovo, Mt. Žeden, 30. 6. 1998, R, C (GTK);
EM14: Skopje, Laskarci, 30. 6. 1998, H (GTK); Skopje, 20 km W, 29. 6. 1973, C (M.J. & J.P. Duffels, ZMAN); Skopje, 20 km W, 30. 6. 1975, C (J.P. Duffels, ZMAN);
EM15: Mt. Žeden, 2. 7. 1976, C (J. Čingovski, SKO);
EM34: Skopje: Vodno, 5. 7. 1942, C (K. Bogoevski, SKO); Skopje: Vodno, 20. 7. 1942, C (G. Stojanov, SKO);
EM45: Aračinovo, 14. 6. 1997, R (GTK); Orlanci, 14. 6. 1997, R (GTK);
EM53: Katlanovo, 5. 7. 1996, R (GTK);
EM67: Kumanovo, 10 km N, 29. 6. 1975, C (J.P. Duffels, ZMAN);
EM71: Lozovo, Kišino, 15. 6. 1997, R, C (GTK);
FL06: Staro Konsko, 6. 7. 1996, R (GTK).

***Cicadetta montana* s. str. (Scopoli, 1772)**

Cicadetta montana s. str. has been acoustically detected and recorded on Pletvar Pass near Prilep (elevation about 1000 m) and near Mavrovo, where also some specimens most probably belonging to this taxon have been collected. In the collection of the Macedonian Museum of Natural History (SKO) there is also a specimen of presumably the same taxon from Mt. Kožuf but without any acoustic data. A definite proof of identity is at present possible only with bioacoustic or/and

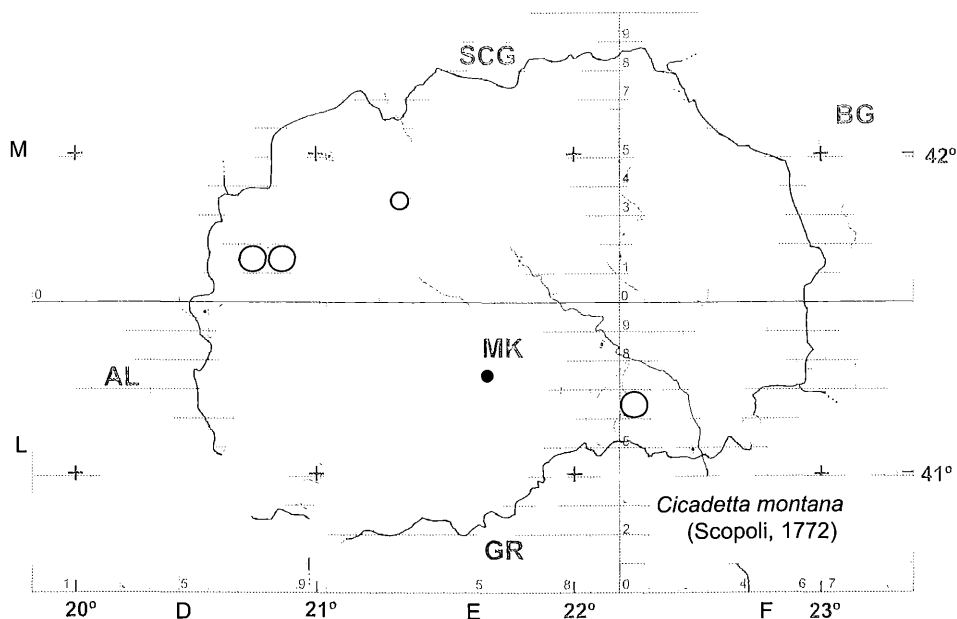


Fig. 10: Distribution of *Cicadetta montana* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

molecular methods (GOGALA & TRILAR 2004). Map with data on geographic distribution in Macedonia is shown in Fig. 10.

DM71: Mavrovo, 24. 6. 1970, C (J. Čingovski, SKO); Mavrovska river, 28. 6. 2000, R (GTK);

DM81: Mavrovo, Leunovo, 22. 6. 1997, C (Krpač, SKO);

EL57: Pletvar, Derven česma, 990 m, 17. 6. 1997, R (GTK);

EM23: Skopje: Breznica, 27. 6. 1997, C (Z. Nikolov, SKO);

FL06: Mt. Kožuf, 27. 7. 1959, C (J. Čingovski, SKO);

Cicadetta macedonica Schedl, 1999

During the survey in the region of Mt. Galičica we discovered a previously unknown taxon of singing cicadas, which has been described by SCHEDL (1999) as *Cicadetta montana macedonica* and later recognized as a good species *C. macedonica* (GOGALA & TRILAR 2004). The song of this species differs substantially from all other related singing cicadas (GOGALA & TRILAR 1999, 2004). In 1998 we detected this species, which is morphologically very similar to *C. montana* s. str., also on Suva Planina near Nova Breznica and in the valley of Garska river in Western Macedonia. Map with data on geographic distribution in Macedonia is shown in Fig. 11.

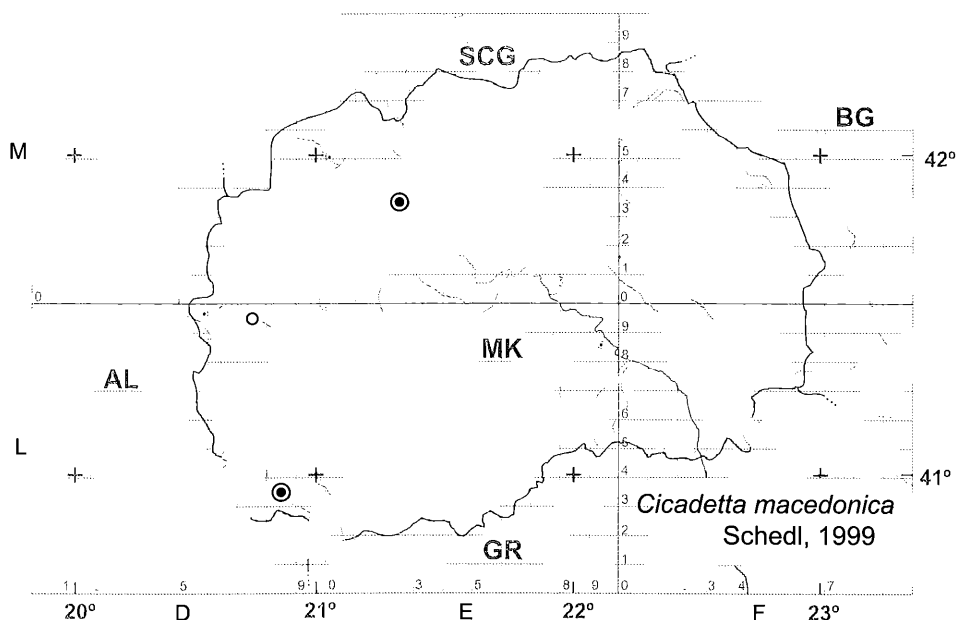


Fig. 11: Distribution of *Cicadetta macedonica* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

DL79: Osoj, near Elenski skok, 19. 6. 1997, H (GTK);

DL83: Mt. Galičica, cableway, 1400 m, 18. 6. 1997, R, C; 5. 7. 1998, R (GTK); Mt. Galičica, 18. 6. 1997, C (V. Krpač, SKO); Ohrid: Gradište, 4. 7. 1998, C (V. Krpač, SKO); Mt. Galičica, 27. 6. 2003, C (V. Krpač, SKO); Mt. Galičica, pass, 1600 m, 18. 6. 1997, H (GTK); Mt. Galičica: Prespa side, 19. 6. 1997, C; 5. 7. 1998, C (V. Krpač, SKO); Mt. Galičica: Leskoec, 5. 7. 1998, C (V. Krpač, SKO); Mt. Galičica, Leskoec, 1050 m, 18. 6. 1997, R, C; 3.-5. 7. 1998, R, C (GTK);

EM23: Skopje, Suva Planina, Nova Breznica, 30. 6. 1998, R, C; 27. 5. 2003, R, C (GTK); Skopje: N. Breznica, 7. 7. 2003, C (V. Krpač, SKO).

Cicadetta cf. podolica (Eichwald, 1830)

In the year 2000 we found in Suva Planina in a spider web a female cicada with a distinct coloration of wings, similar but much more pronounced as in *C. podolica*. In the year 2003 we succeeded to hear and record the song and to collect males and females of this cicada population. After comparison of this isolated Macedonian population with the typical *C. podolica* from Poland we found morphological and acoustic differences which are important enough to consider it as a distinct (sub)species. A detailed description of this taxon will be published separately but the song pattern has been published already (GOGALA & TRILAR, 2004). Additional material from the same region has been collected later by S.D. Davkov and became

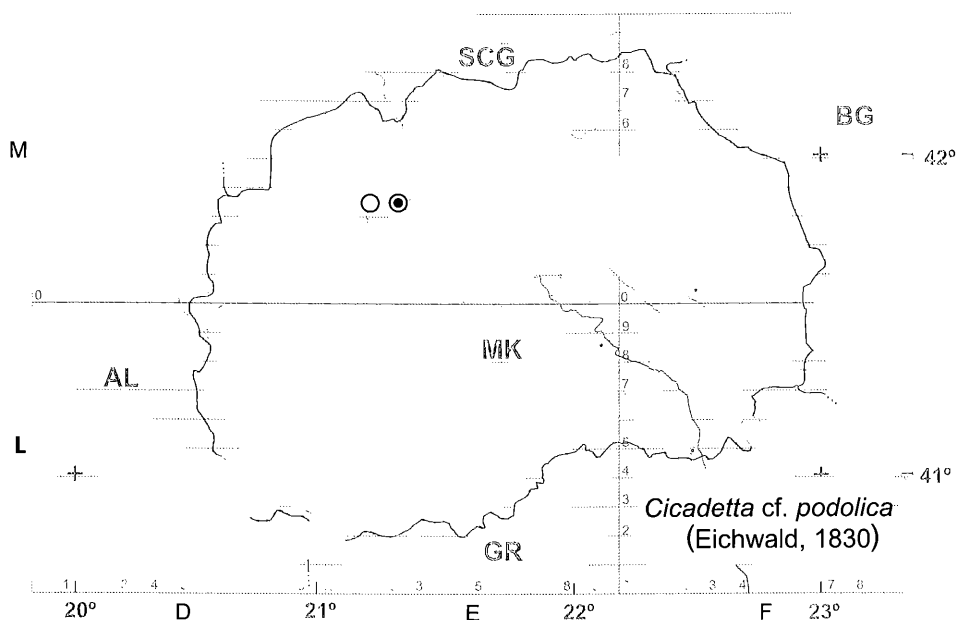


Fig. 12: Distribution of *Cicadetta cf. podolica* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

available through J.P. Duffels and David Emery from Australia. Map with data on geographic distribution in Macedonia is shown in Fig. 12.

EM13: Skopje: Treska Canyon, 1160 m, 15. 6. 2004, C (S.D. Davkov);

EM23: Skopje, Nova Breznica, Suva Planina, 1100 m, 4. 7. 2000, C (GTK); 6.-8. 7. 2003, R, C (GTK).

***Cicadetta cerdaniensis* Puissant & Boulard, 2000**

Cicadetta cerdaniensis is another species of the *C. montana* complex found in Macedonia. This species was surprisingly found on Suva Planina near Nova Breznica in the same time period and on the same meadows as *C. cf. podolica* and very close to the shrubs with *C. macedonica*. According to recent data the species is distributed all over Europe (GOGALA & TRILAR 2004, HERTACH 2004, TRILAR & HOLZINGER 2004). The song has been described by PUISSANT & BOULARD (2000) as well as by GOGALA & TRILAR (2004). Map with data on geographic distribution in Macedonia is shown in Fig. 13.

EM23: Skopje, Nova Breznica, Suva Planina, 25. 5. 2003, R, C; 6.-8. 7. 2003, R, C (GTK); Skopje: N. Breznica, 7. 7. 2003, C (V. Krpač, SKO).

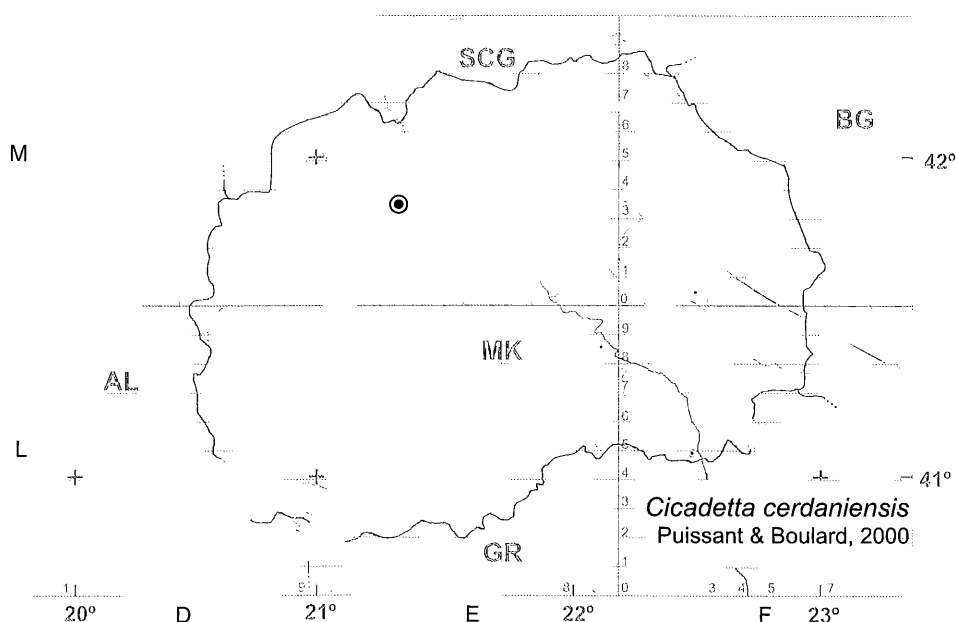


Fig. 13: Distribution of *Cicadetta cerdaniensis* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

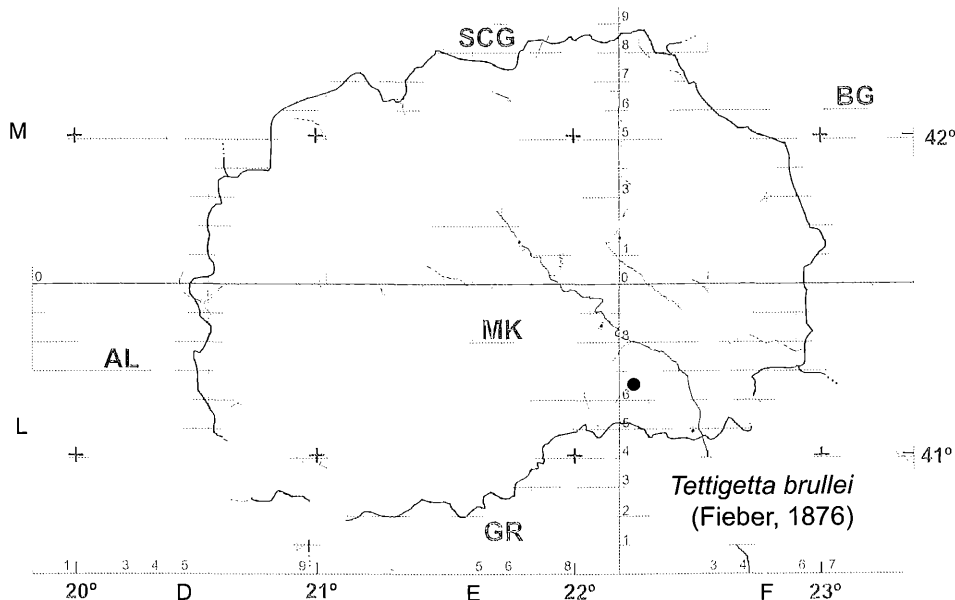


Fig. 14: Distribution of *Tettigetta brullei* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

***Tettigetta brullei* (Fieber, 1876)**

Small cicadas of this species have been detected and recorded in the southern part of Macedonia. Its song has been briefly described by BOULARD (1995) as *Tettigetta pygmaea* (Olivier, 1790) and in more details by POPOV et al. (1997). Map with data on geographic distribution in Macedonia is shown in Fig. 14.

FL06: Staro Konsko, 520 m, 6. 7. 1996, R (GTK).

***Tettigetta dimissa* (Hagen, 1856)**

Tettigetta dimissa is widely spread in Macedonia. There are specimens in the collection of the Macedonian Museum of Natural History (SKO) and other collections and we heard and recorded the characteristic song (GOGALA & POPOV 2000) of this species in many localities. Map with data on geographic distribution in Macedonia is shown in Fig. 15.

DL79: Osoj, near Elenski skok, 19. 6. 1997, H (GTK);

DL83: Ohrid, Peštani, Gradište, 700 m, 4. 7. 1998, R, C (GTK); Ohrid, Trpejica, 750 m, 18. 6. 1997, H (GTK); Ohrid: Gradište, 4. 7. 1998, C (V. Krpač, SKO);

DL84: Ohrid 600 m, 2.-16. 7. 1997, C (H.A. & O. Coene, ZMAN);

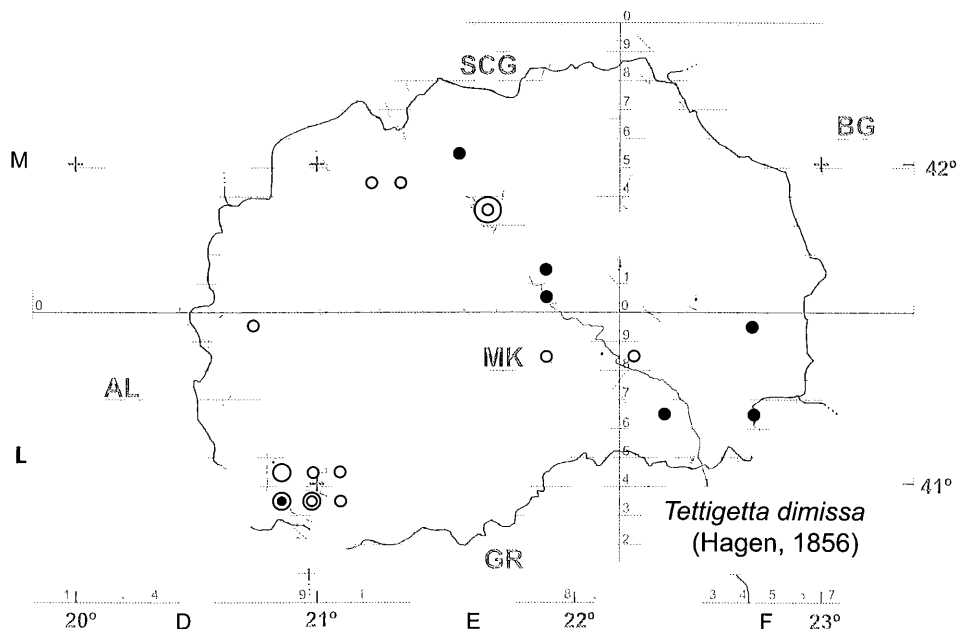


Fig. 15: Distribution of *Tettigetta dimissa* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

- DL93:** Mt. Galičica, Leskoec, 1050 m, 18. 6. 1997, H; 3.-5. 7. 1998, H (GTK); Prespa lake: Oteševo, 26. 7. 2003, C (V. Krpač, SKO);
- DL94:** Prespa, D. Perovo, 18. 6. 1997, H (GTK);
- EL03:** Resen, Pretor 850 m, 3. 7. 1998, H (GTK);
- EL04:** Prespa, Lavci, 18. 6. 1997, H (GTK); Prespa, Pokrvenik, 18. 6. 1997, H (GTK);
- EL78:** Drenovo, 17. 6. 1997, H (GTK);
- EM14:** Skopje, Laskarci, 30. 6. 1998, H (GTK);
- EM24:** Skopje, Arnakija, 30. 6. 1998, H (GTK);
- EM45:** Aračinovo, 14. 6. 1997, R (GTK);
- EM53:** Kožle, Pčinja, 1. 7. 1998, H (GTK); Skopje: Railway station Pčinja, 7. 7. 1942, C (K. Tuleškov, SKO); Skopje: Railway station Pčinja, 7. 7. 1942, C (K. Bogoevski, SKO);
- EM70:** Ubogo, Bregalnica, 15. 6. 1997, R (GTK);
- EM71:** Lozovo, Kišino, 15. 6. 1997, R (GTK);
- FL08:** Demir Kapija, 1. 7. 1998, H (GTK);
- FL16:** Staro Konsko, 520 m, 6. 7. 1996, R (GTK);
- FL46:** Dojran, Ačikot, 5. 7. 1996, R (GTK);
- FL49:** Strumica, Hamzali, 305 m, 2. 7. 1998, H (GTK); Strumica, Hamzali, 390 m, 2. 7. 1998, R (GTK).

Pagiphora annulata (Brullé, 1832)

Pagiphora annulata is very abundant species in Macedonia. Songs were recorded and described for the first time during our investigations (GOGALA & TRILAR 2000). The only previous description of acoustic signals of any *Pagiphora* was published by BOULARD for *P. yanni* (1992a). Both species of this genus have a surprisingly low frequency band for such relatively small animals (BENNET-CLARK & YOUNG 1994). BOULARD (1992a) reports for *P. yanni* the spectral range between 4 and 9 kHz and in our recordings of *P. annulata* we measured the main energy even at frequencies between 3 and 5 kHz. According to BENNET-CLARK & YOUNG (1994) the emitted frequency of such small cicada should be around 12 kHz. Even considering just tymbal parts of the song, the frequencies are far from the expected range. To show clearly this discordance we added our data to the plot published by these authors (Fig. 17). In *P. annulata* wings are involved in sound production (GOGALA & TRILAR 2003). Map with data on geographic distribution in Macedonia is shown in Fig. 16.

DL83: Ohrid, Peštani, Gradište, 700 m, 4. 7. 1998, R, C (GTK); Ohrid: above Gradište, 4. 7. 1998, C (V. Krpač, SKO);

DM71: Mavrovo, 3. 7. 1982, C (Topukova, SKO);

EM04: Cerovo, Mt. Žeden, 30. 6. 1998, R, C; 28. 6. 2000, R; 6. 7. 1998, R (GTK); Tetovo: Cerovo, 30. 6. 1998, C (V. Krpač, SKO);

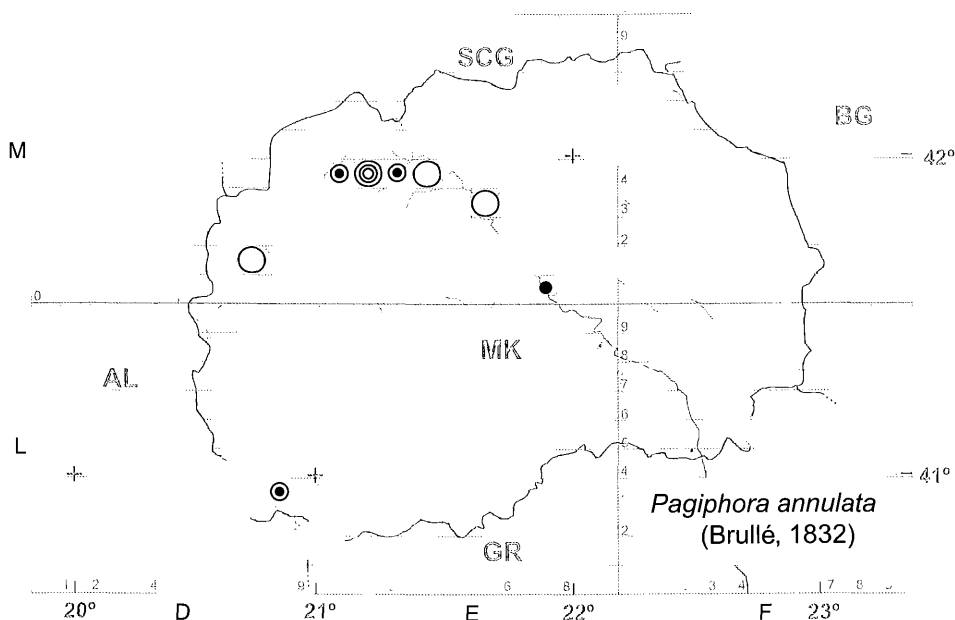


Fig. 16: Distribution of *Pagiphora annulata* in Macedonia. Explanation of symbols is shown in the caption of Fig. 2.

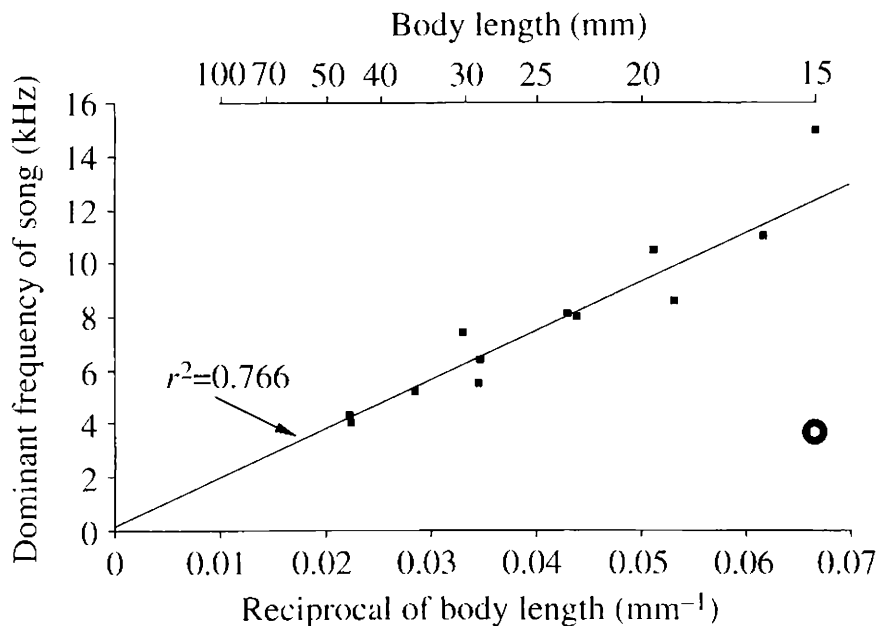


Fig. 17: Graph of dominant frequency in the song versus the reciprocal of body length for the 16 cicada species reproduced from BENNET-CLARK & YOUNG (1994 - Fig. 1). The bold circle shows the value for the tymbal sound of *Pagiphora annulata* (with permission from authors and the *Journal of Experimental Biology*).

EM14: Skopje: Laskarci, 30. 6. 1998, C (V Krpač, SKO); Skopje, 20 km W, 29. 6. 1973, C (M.J. & J.P. Duffels, ZMAN); 30. 6. 1975, C (J.P. Duffels, ZMAN); Skopje, Laskarci, 30. 6. 1998, H (GTK);

EM24: Skopje, Arnakija, 30. 6. 1998, R, C (GTK);

EM34: Skopje, 13. 7. 1954, C (P. Ivanovski, SKO);

EM53: Skopje: Katlanovo, 15. 7. 1959, C (J. Čingovski, SKO);

EM70: Ulanci, Solena Dolina, 7. 7. 1998, R (GTK).

Discussion

From the distribution maps (Figs 1-5, 7-16) it is evident that from some regions in Macedonia until now we do not have any data for singing cicadas. These regions are Šar planina and Polog, north-eastern part (Kriva Palanka, Kočani), extreme South East and also southern part of Macedonia (Pelister, Mariovo and Kajmakčalan). Also some mountains in the central part of Macedonia, like Jakupica, are not yet properly investigated. Nevertheless, the number of the species is not low and some of the findings are really surprising, like *C. persica* and the discovery of endemic *C.*

macedonica. Some other species can still be expected like *Cicada mordoganensis*, *Cicadetta flaveola* and some other *Cicadetta* and *Tettigetia* species known from Greece and other countries in the vicinity. The presence of *T. steveni* in Macedonia is uncertain. The locality "Petrič", quoted in JANKOVIĆ (1971), is in Bulgaria and not in the Republic of Macedonia. Therefore, the number of species of singing cicadas found in Macedonia with certainty, is fifteen at the moment.

DLABOLA (1964) listed for Albania 9 species of singing cicadas including *Tibicen* (= *Tibicina*) *haematodes* f. *viridinervis* and "*Cicadatra concinna*", which are not found in Macedonia. However, it is unclear what he meant by the latter synonym. According to SERVADEI (1967) and NAST (1972), *C. concinna* is a junior synonym of *C. atra* (see DUFFELS & VAN DER LAAN, 1985) while BOULARD (1981) claims that this is a synonym of *Cicadetta podolica*.

We never found *Tibicina haematodes* f. *viridinervis* in Macedonia. Surprisingly, Dlabola did not find in Albania *Cicadatra hyalina* nor *C. platyptera* or *C. persica*.

It should be mentioned that there are no comprehensive faunistic papers about singing cicadas in Greece or Bulgaria till now, and even for Serbia inclusive Kosovo there is only a small number of cicadas (11) reported till now (JANKOVIĆ, 1978).

An interesting question is the distribution of various species of *C. montana* complex. Till now we know that at least 3 species of this complex plus *C. cf. podolica* occur in Macedonia, but we can expect some more, at least *C. brevipennis* (recorded from S.E. Romania) and possibly the new species recently discovered in the central and southern Greece (GOGALA & DROSOPOULOS, personal communication).

The aim of this paper is not to analyze in details the songs of different singing cicadas from Macedonia. Nevertheless, we added some important additional data on the song of *C. platyptera*, not published anywhere before and pointed out also the surprising frequency characteristics of the song of *P. annulata*.

To improve our knowledge on singing cicadas of Macedonia, data from various foreign collections should be included and more field work with the use of bioacoustic methods should be done in the future.

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