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Evaluation of Morphological and Bioacoustics Characteristics of *Cicadivetta tibialis* (Panzer, 1798) (Cicadoidea: Tibicinidae) According to Samples Collected from the South East Mediterranean Region of Anatolia in Turkey

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ABSTRACT

In this study, in terms of morphological and bioacoustics population of *Cicadivetta tibialis* from South East Mediterranean Anatolia of Turkey were studied and compared with data from the literature. The morphological features revealed that sample species have not exhibited significant variations according to literature. The sound of the species posses one type of song and this is consist of two phrases: Phrase I and II. The calling song begins in phrase I and continues for minutes (0.84-2.56 s) after the animal sharp to phrase II and continues for about four to nearly eight minutes (5.53-7.47 s), then phrase I repeated. Phrase I evaluated with T1, T2, T3, T4, T5, T6, T7, and T10 parameters. In addition to previous studies, we take into account of T10 which is first T3. All of the data are evaluated by using simple statistical methods and evaluated the spectrum of calling song.

Key words: *Cicadivetta tibialis*, morphology, acoustics, Mediterranean Region, Turkey.

INTRODUCTION

Morphology has very important taxonomic characteristics for most Hemiptera species (Quartau, 1988; Moulds, 2005; Zeybekoğlu *et.al*., 2011). In addition to morphological characteristics, acoustic characteristics are very useful in determining the relationships of species among *Hemiptera cicadas* (Claridge, 1985; Sueur and Puissant, 2000; Zeybekoğlu *et al*., 2011; Hertach *et al*., 2015). The songs of the several group of cicadas have been used for solving taxonomic problems e.g. discrimination between sibling species or establishing the status of local populations showing small morphological differences (Gogala *et al*., 2009). One of this genus is *Cicadivetta* Boulard, 1982 belonging to subfamily Tibicinidae.

Cicadivetta Boulard, 1982 is distributed across Europe, North Africa, the Middle East, and eastern Asia (Mozaffarian and Sanborn, 2010; Gogala *et al*., 2016) and its acoustic characteristics were used to discriminate the species of this genus because it has a lot of sibling species (Gogala *et al.,* 2016).

Önder *et al.,* (2011) reported that *Cicadivetta* Boulard, 1982 is represented with *Cicadivetta tibialis* (Panzer, 1798) in Turkey. This species was indicated as an agricultural pest (Kaplan and Tezcan, 2016) and recorded from two Turkish cites, Ankara and Izmir. The aims of this study are i) to review the *Cicadivetta tibialis* (Panzer, 1798), using morphology and bioacoustics characteristics collected from the South East Mediterranean Region of Turkey, ii) to reveal properties of songs elements by using quantitative and qualitative data, and iii) to present some comment on its vegetation preference.

MATERIAL AND METHODS

Collecting specimens

This study was carried out during 2015 in South East Mediterranean Region of Turkey (Fig. 1). The *Cicadivetta* specimens were collected by a sweep net after songs were recorded during the field work. The song recorded specimens were labelled and deposited in 96 % ethyl alcohol solutions. Specimens collected during the field studies were prepared as museum material by standard methods. Male genitalia were dissected and soaked into aqueous at room temperature. Figures and measurements were obtained using a digital camera attached to the stereo microscope. For the traditional cicadas morphological terminology; Quartau, (1988); Moulds, (2005); Zeybekoglu *et al.,* (2011); Mol *et al*., (2013), for Cicadas song terminology; Gogala *et. al*., (1996) and for temporal parameters Trilar and Gogala, (2010) were used. All of data were evaluated by using simple statistical methods and the spectrum of calling song was evaluated. This specimens were identified using by Joermann and Schneider, (1987); Gogala and Trilar, (2014); Gogala and Drosopoulos, (2006), and Gogala *et al*., (1996, 2011, 2016). The examined specimens in this study were deposited in Aksaray University Central Research Laboratory, Entomological Museum, ASUBTAM (Aksaray/Turkey).

Fig. 1. Distribution of *Cicadivetta tibialis* in Turkey.

Song recording and analysis

Song recordings of collected animals were made in the field. All song records were carried out by TASCAM DR-100MKII recorder using Philips-SBC ME 570 condenser microphone (frequency response from 50 to 20000 Hz) and Audio Technica Condenser short shotgun microphone (up to 22000 Hz). The microphone was kept about 5-15 cm away from the calling male. The male songs were digitalized at 48000 Hz and analyzed with Sony Sound Forge Audio Studio 9.0, Cool Edit 96, and Turbolab 4.0 (Stemmer AG). The traditional cicadas song terminology (Claridge, 1985; Gogala and Drosopoulos, 2006; Gogala *et.al.,* 1996; Zeybekoğlu *et.al.,* 2011) was used to diagnose the songs. In this study the duration of T10 (Gogala *et al.*, 1996 evaluated first T3 echeme duration) was measured. The following terms were used: *calling song*, song produced by an isolated male; *phrase*, a first-order assemblage of echeme, and the echeme the repeated unit of phrase. In song descriptions seconds (s) or milliseconds (ms) were used for duration/intervals.

RESULTS

Cicadivetta tibialis (Panzer, 1798)

Cicadetta tibialis (Panzer): Nast 1972: 154; *Cicadetta tibialis* (Panzer): Duffels and Laan, 1985: 274; *Cicadivetta tibialis* (Panzer): Joermann and Schneider, 1987: 291-293, 295; *Cicadivetta tibialis* (Panzer): Boulard, 1995: 71, 72; *Cicadetta tibialis* (Panzer): Gogala *et.al.*,1996: 45-62; *Cicadivetta tibialis* (Panzer): Önder *et.al.,* 2011: 6; *Cicadivetta tibialis* (Panzer): Kaplan and Tezcan, 2016: 173-183.

Tettigonia tibialis (Panzer, 1798) syn.

Cicadetta caucasica (Kolenati, 1975) syn.

Cicadetta tibialis (Panzer, 1798) syn.

Morphology

Material examined: TURKEY: Adana: Saimbeyli, Obruk Plateu, Saksagan passage, 09.07.2015, 1678 m., N 38°11.19, E 036°11.42, 5♂♂, 2 ♀♀, Leg. A. MOL.

Description

The body length from the head to tip of abdomen is 9.5-13.2 in males, 11-12 mm in female and the body length from the head to tip of tegmina is 16-18 in male, 16-19 mm in females. Tegmina 10.3-14 mm in male, 9.6-12 mm in female, and in width are 4.2-4.5 in males, 3.84-4.35 mm in females (Table 1).

Male and Female

Head, frons, and postclypeus yellowish are black, middle of the ocellus, supra-antennal plate and edge of rostrum blackish-yellow in male and light in female. Rostrum reaching the end of the second or middle of the third coxa in both sexes. Pronotum black, lateral angles of pronotal collar pronounced and blackish-brown

in male, yellowish-brown in female. Posterior part of pronotal colllar produced middle of pronotum as triangular, sometimes mesonotum with this shape semicircle. Mesonotum blackish and sometimes brownish with H shape in female. Surround of scutal depression and cruciform elevation blackish-brown in male and yellowish brown in female. Mesonotal posterior ridge near the wing groove blackish in male (Fig. 2) and yellowish-brown in female.

Abdominal tergum blackish yellow, sternum 1 in between of the timbals black and others blackish with yellowish-brown markings in male. Sternums yellowish in female (Fig. 3).

Coxa and trochanter yellowish with blackish markings, sometimes blackish-yellow. Front femora with three big and one small spines; tibiae generally brownish black in male, yellowish brown in female; tarsus basally blackish-brown in male, yellowish brown in female. Pretarsal claws blackish in male, yellowish in female. Opercula kidney-shaped, blackish basally and yellowish-brown apically in male, not overlapping, broadly rounded, with sinuous yellow spine (meracanthus) (Fig. 4) in male. Sternite VIII yellow, longer than sternite VII (Figs. 5A, 5B). Abdominal segments triangular in cross section, dorsally forming a rounded ridge.

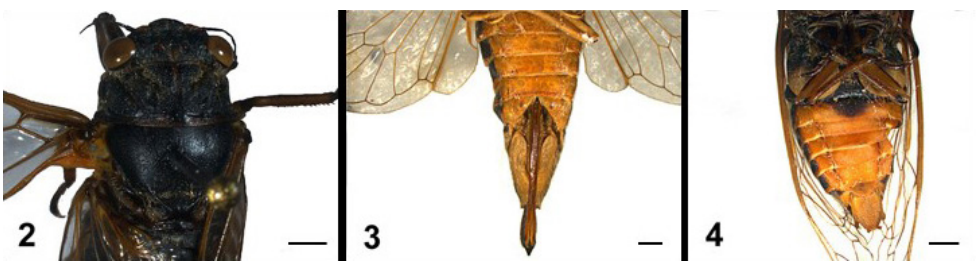
Tegmina and hind wings transparent, without markings, 2.3-2.6 times as long as wide in male and 2.4-2.5 times in female. The numbers of apical cells on front wings are 8 in both sexes and on hind wings 6 in male, 5 in female. Ulnar cell is 1.25-1.42 times longer than apical cell 1 in male and 0.85-1 times in female. Bacal cell of the temina transparent, basal membrane yellowish to oranges. The base of the costal cell with yellowish of hind wings. Veins yellowish basally, brownish apically (Fig. 6). Head, apical part of pronotum, paramedian and lateral fissure, behind of the eyes, gena, lorum, coxa, trochanter, femur, tibia, anepisternum, katepisternum, anepimeron, and first abdominal sternum dense setae.

Pygophore ventral half blackish, aedeagus pale brownish (Fig. 7). Basal lobe of the pygophore near the apical spine of the pygophore. Median lobe of the uncus nearly same length of dorsal beak of pygophore, lateral process of uncus blackish, anal tube blackish, anal styles yellowish brown upper lobe of the pygophore with dorsal beak and pygophore with dentate in the middle (Fig. 8). Aedeagus short (Fig. 9) 1.2-1.6 mm, shape of as a crescent, tip of the basal plate and gonophore of it bump, both of pseudoparamere connected with nearly half of it; ovipositor length 3.93-4.68 mm. Shape and coloration of the genital segment is shown Fig.10. The overall coloration is black with brown, pale yellow and brown markings. Sternites with yellowish bands (Fig. 11), female lighter than male (Fig.12).

Acoustics

As previous literature mentioned (Joermann and Schneider, 1987; Gogala *et. al.*, 1996; Sueur and Puissant, 2000), the sound of the species contain only one type of the song- the calling song- produced by alone male and this song comprise two phrases (Phrase I and Phrase II). Phrase I started with a series of short echemes, varying in number between 2 and 15, followed by a long echeme (Fig. 13-15). As it is mentioned Gogala *et al.,* (1996), in this study in terms of phrase I elements evaluated seven

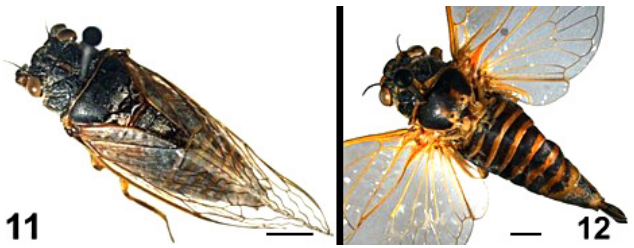
different category (T1, T2, T3, T4, T5, T6, T7), and we study echemes account of one phrase. Gogala *et al.,* (1996) did not study T10. The first T3 was generally considered to be T10 because it was shorter than the subsequent T3 and compared to other T3. According to our data, the duration of T1, 159-346 ms (224.2±47.8); the duration of T2, 842-2563 ms (1558.2±493.4); the duration of T3, 14-45 ms (27.2±5.85); the duration of T4, 16-26 ms (19.9±2.21); the duration of T5, (11-157) ms (111.49±22.66); the duration of T6, 89-299 ms (115.36±29.04); the duration of T7, 12-56 ms (31.28±11.26); the duration of T10, 16-30 (20.77±2.87), and the number of the T3 in phrase 5-15 (9.5±2.85). Phrase II; the duration of T8, 16-53 ms (31.51±7.94), and the duration of T9, 45-205 ms (123.74±18.15) (Table 2).



Figs. 2-4. *Cicadivetta tibialis* 2. Male frons, head,pronotum, and mesonotum (scale= 2.2 mm). 3. Female abdominal sternum (scale= 4 mm). 4. Male opercula kidney-shaped with meracanthus (scale= 3.8 mm).

Figs. 5, 6. *Cicadivetta tibialis* 5A. Sternite VII (scale= 1 mm). 5B. Sternite VIII (scale= 1 mm). 6. Left male tegmina (scale= 4.1 mm).

Figs. 7-10. *Cicadivetta tibialis* 7. Lateral view of male genitalia (scale= 400 um). 8. Lateral view of pygfore (scale= 0.6 mm). 9. Lateral view of aedeagus (scale= 1.3 mm). 10. Above view of female genitalia (scale= 1.8mm).



Figs. 11, 12. *Cicadivetta tibialis* 11. Lateral view of male (scale= 4.3 mm). 12. Above view of female (scale= 2.5 mm).

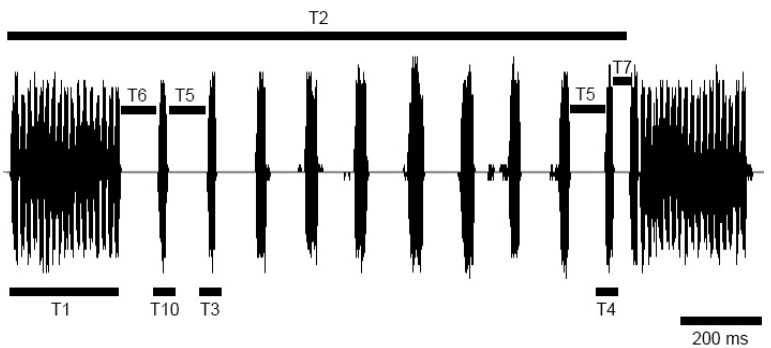


Fig. 13. *Cicadivetta tibialis* oscillogram of T1 (scale= 200 ms).

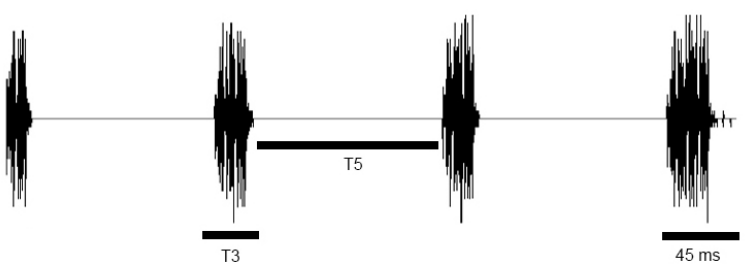


Fig. 14. *Cicadivetta tibialis* oscillogram of T3 and T5 (scale= 45 ms).

Fig. 15. *Cicadivetta tibialis* oscillogram of Phrase II, T8 and T9 (scale= 150 ms).

Fig. 16. *Cicadivetta tibialis*, study area (Photo Dr. Deniz ŞİRİN).

CONCLUSION

Cicadivetta tibialis (Panzer, 1798) has a wide distribution across North Africa, Europe, the Middle Asia, Asia Minor including Iran (Mozaffarian and Sanborn, 2010). There is no exhaustive study both using morphology and bioacoustics in terms of *C. tibialis* of Turkey population and it is rarely mentioned in mainly faunistic lists and as a agricultural pest (Önder *et. al.,* 2011; Kaplan and Tezcan, 2016). In terms of male outer genital organs, specimens are similar to those in the Caucasus region (Gogala *et.al.,* 1996) (Table 1). Such as the posterio-ventral margin of pygophore convex of our specimens (smooth in Balkan population). Means for 16 morphometric characters measured from five males and two females from East Mediterranean populations belonging to *C. tibialis* was given Table 1.

During our recent field studies, we did not only collect material but also recorded male calling song of this species. Phrase I was evaluated with T1, T2, T3, T4, T5, T6, T7, and T10 parameters and was similar with previous studies. In addition to previous studies, we take T10 into account which is first T3. According to our data T10 duration (20.76±2.87) less than T3 (27.2±5.85). Although specimens are not equal in both parameters, we think that T10 should be separate from T3 (Table 2).

The spectrum of calling song contains two frequency bands: a main one between 15 and 19 kHz with a maximum between 16 and 18 kHz and a second band of 7 and 8 kHz. According to our the data, in first band the first frequency is higher than Gogala *et.al.,* (1996) reported to be 12 kHz and the second frequency is lower than that of Gogala *et.al.*, (1996) reported 22 kHz. The second band frequency similar is with Gogala *et.al.,* (1996).

Ecology. Individuals of the *C. tibialis* (Panzer) were found on various *Pinus* spp., deciduous trees, shrubs, and graminous in the altitudes above 1650 m (Fig.16). The density of the singing males was very high. We recorded male calling song of *Cicada mordoganensis* Boulard, 1979 and *Lyristes isodol* Boulard, 1988 below this locality.

It is concluded that Cicadoidea species of Turkey need to be revised by using especially acoustics characteristics.

Table 1. Means for 16 morphometric characters measured from five males and two females from East Mediterranean populations belonging to Cicadivetta tibialis (Panzer, 1798)

Characters (for both sexes) mm	*Cicadivetta tibialis* (Panzer, 1798)		
		Male	Female
Tip of the crown to apical margin of the right forewing	Range m N	16-18 17 5	16-19 17.5 2
Body length (Tip of the crown to tip of the abdomen)	Range m N	9.5-13.2 11.7 5	11-12 11.5 2
Medial length of crown	Range m N	0.75-1.12 0.93 5	0,82-0.86 0.84 2
Minimum distance between ocular stures	Range m N	1.40-1.58 1.49 5	1.53-1.32 1.43 2
Mediallength of frons	Range m N	0.29-0.47 0.39 5	0.28-0.40 0.34 2
Mediallength of pronotum	Range m N	1.32-1.50 1.39 5	1.3-10.39 1.35 2
Mediallength of mesonotum	Range m N	1.85-2.05 1.95 5	1.8-2.1 1.95 5
Lengthof right forewing	Range m N	10.3-14 12.4 5	9.6-12 10.8 2
Lengthwidthof rightforewing	Range m N	4.2-4.5 4.35 5	3.84-4.35 4 2
Length of ulnarcell 1	Range m N	2.9-3.0 2.85 2	1.28-1.61 1.45 2
Length of dorsal margin of the left fore femur	Range m N	1.72-.1.90 1.80 5	1.5-1.7 1.60 2
Length of anterior margin of basal cell	Range m N	0.9-1.02 0.97 5	0.83-1.03 0.93 2
Distance from anterior right corner to posterior left corner of left operculum	Range m N	1.72-2.00 1.80 5	-
Length of pygofore in lateral view	Range m N	1.2-1.65 1.52 4	-
Aedeagus length	Range m N	1.2-1.6 1.4 3	-
Hypandrium length (male)/Ovipozitor length (female)	Range m N	1.69-1.9 1.78 6	3.93-4.68 4.3 2

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Table 2. Temporal parameters of the calling song of *Cicadivetta tibialis*.

	Parameter	Unit	Number	Min	Max	Mean	St.Dev.
Phrase I	T1	ms	56	159	346	224.2	47.8
	T2	S	55	842	2563	1558.2	493.4
	T3	ms	416	14	45	27.2	5.85
	T4	ms	54	16	26	19.9	2.21
	T5	s	403	11	157	115.49	21.66
	T6	ms	53	89	299	115.36	29.04
	T7	ms	53	12	56	31.28	11.26
	T10	ms	55	16	30	20.76	2.87
	Echeme count		55	5	15	9.5	2.85
Phrase II	T8	ms	152	16	53	31.52	7.94
	T9	ms	126	45	205	123.74	18.15

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