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Original article

Some notes to morphological and bioacoustics characteristics of *Cicadatra hyalina* (Fabricius, 1798) (Cicadoidea: Cicadidae) according to samples collected from different parts of Turkey

Türkiye'nin farklı bölgelerinden toplanan örneklerle *Cicadatra hyalina* (Fabricius, 1798) (Cicadoidea: Cicadidae)'nın morfoloji ve biyoakustik karakterleriyle ilgili bazı notlar

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ABSTRACT

In this study, *Cicadatra hyalina* (Fabricius, 1798), known to be economically important due to species damages to agricultural and cropland areas especially in the nymph phase, was researched in regard to morphology, bioacoustics, variation and some ecological characteristics. Some variations such as coloration and important morphological characteristics of species were given. Calling song consist of continuous signal and echeme song. Continuous signal variable, lasting 1.3-9 minutes or longer, after some minutes continuous signal change into a short echeme song, which is regulary repeated and lasts 1710 ms on average. The gap duration between echemes is 450 ms. In addition to previous records, *C. hyalina* was collected from new localities such as Bayburt, Burdur, Çorum, and Malatya. The study is supported with illustrations.

INTRODUCTION

Cicadatra Kolenati, 1857 is distributed primarily in Europe, North Africa, and Central Asia with more than 40 species (Boulard et al. 2018, Duffels and Laan 1985, Kartal and Zeybekoğlu 1999, Mozaffarian and Sanborn 2010, Nast 1972, Simoes et al. 2013). It is revealed in many cases that the best method for the detection and discrimination of sibling species of Cicadas is by recording and analyzing their acoustic characteristics (Boulard 1995, Boulard et al. 2018, Claridge 1985, Drosopoulos et al. 2006, Mol et al. 2013). Some of them are *Cicadatra hyalina* (Fabricius, 1798) which damage the agricultural and cropland areas.

According to Mozaffarian and Sanborn (2010), *C. hyalina* (Fabricius, 1798) is known from the Balkan Peninsula, Turkey, Syria, Jordan, Iran, Georgia, Russia Armenia, Transcaucasia, and Caucasus.

Lodos and Kalkandelen (1981) reported that studies of *C. hyalina* in Turkey started with Hagen (1857), Horvath (1901), Fahringer (1922), and Dlabola (1957). After then, in recent decades, Boulard (1995), Kartal and Zeybekoğlu (1999), Kaplan and Tezcan (2016), and Önder et al. (2011) provided significant information about this species. However, it seems that there are still some uncertainties and deficiencies in knowledge of the *C. hyalina* population in Turkey.

In this study, by collecting *C. hyalina* specimens from different parts of Turkey, the aim is (i) to review *C.*

hyalina (Fabricius, 1798) thoroughly using morphological characters; (ii) to describe calling songs with variation, and (iii) to evaluate their relationship with the closely related species in terms of some morphological and acoustics characteristics.

MATERIALS AND METHODS

Specimens collecting

This study was carried out between the years 2012-2015, Cicadas specimen were collected in different parts of Turkey (Figure1) and localities were chosen randomly. During the field work, songs of the specimens were recorded and then they were collected by a sweep net. After the recordings, specimens were labelled and deposited in alcohol (96%). Specimens were prepared as museum material by standart methods. Male genitalia dissected and soaked into aqueous at room temperature. Figures and measurements were obtained through digital camera or camera lucida attached to the stereo microscope. Dantsig et al. (1964), Quartau (1988), Kartal and Zeybekoğlu (1999), Moulds (2005), Zeybekoglu et al. (2011), Mol et al. (2013) and Boulard et al. (2018) were used for cicadas morphological terminology and diagnose specimens. Specimens examined in this study are deposited in Aksaray University (Central Research Laboratory, Entomological Museum, ASUBTAM). All specimens were collected by the author except the ones from Bursa and Muğla provinces.

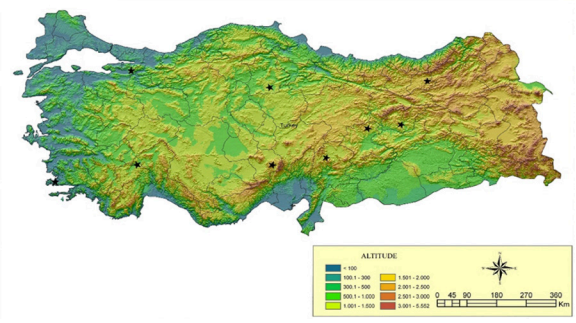

Figure 1. Specimens' collection area of *Cicadatra hyalina* from Turkey

Song recording and analysis

Males of *Cicadatra hyalina* (Fabricius, 1798) make sounds by using their timbals (Claridge 1985). Song recordings were made in the field using TASCAM DR-100MKII recorder with 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. Male calling song was recorded, after then specimens were deposited in 96% ethyl alcohol solutions. Recordings were transferred to the hard-disk of a laptop computer and were analysed. The male songs were digitalized at 48000 Hz and Sony Sound Forge Audio Studio 9.0 and Cool Edit 96 (to define morphology, to measure and to analyse the frequency of the calling song) and Turbolab 4.0 (Stemmer AG) were used to print in JPG format. To study, the specimens were identified as *C. hyalina*, the song patterns were compared with Boulard (1995) and Boulard et al. (2018). Gogala et al. (1996), Sueur (2002), Simoes et al. (2013) and Mol et al. (2013) were used to diagnose the songs. Calling songs were recorded from three different localities (Burdur, Niğde, Kahramanmaraş) and eight different males. The temperatures at the time of the recording are 34, 32, 30°C respectively. Male calling song figures are given in this article belonging to Kahramanmaraş population. The following terms were used for song characteristics. Calling song: song produced by an isolated male and consist of continuous song and echeme phrase (mentioned rumbling song in Boulard et al. 2018). Phrase: a first-order assemblage of echeme and the echeme repeated unit of phrase. Echeme consist of syllable and syllable consist of pulses. In song descriptions minute, seconds (s) or milliseconds (ms) were used for duration/intervals.

RESULTS

Cicadatra hyalina (Fabricius, 1798)

Cicadatra hyalina Fabricius 1798: Fieber 1876: 50; *Cicadatra hyalina* (Fabricius 1798): Horvath 1901: 482; *Cicadatra hyalina* (Fabricius): Dlabola 1981: 205; *Cicadatra hyalina* (Fabricius): Duffels and Laan 1985: 159; *Cicadatra hyalina* (Fabricius): Boulard 1995: 28, 29, 31; *Cicadatra hyalina* (Fabricius): Kartal and Zeybekoğlu 1999: 63-66; *Cicadatra hyalina* (Fabricius): Schedl 1999: 825, 834; *Cicadatra hyalina* (Fabricius): Gogala et al. 2005: 110; Boulard et al. 2018.

Morphology-male and female

Head and frons, generally blackish yellow, rarely blackish; postclypeus yellowish black; middle of the ocellus and supra-antennal plate blackish-yellow in both sexes (Figure 2). Ocellus dark brown or yellowish. Rostrum reaching the end of the second or middle of the third coxa in male, reaching the end of the second coxa in female; middle of the rostrum yellowish, and edge of it, blackish yellow in both sexes (Figure 3).

Sometimes dorsal part of it yellow in females; Pronotum blackish yellow, sometimes blackish brown in males and yellowish in females; lateral angles of pronotal collar pronounced, and blackish-brown or blackish yellow in male, yellowish-brown in female. Posterior part of pronotal

Figure 2. Male, head and pronotum

Figure 3. Male, head apparatus

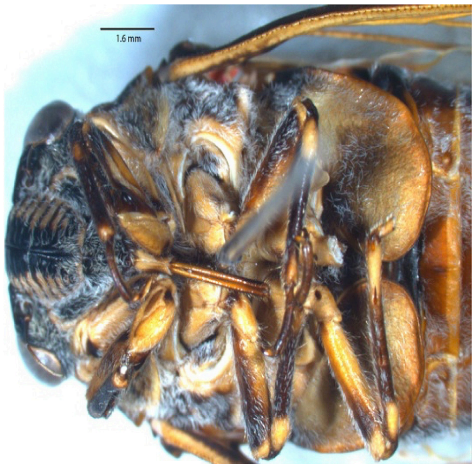

Figure 4. Male frons, operculum

Figure 5. Male pygofer from lateral

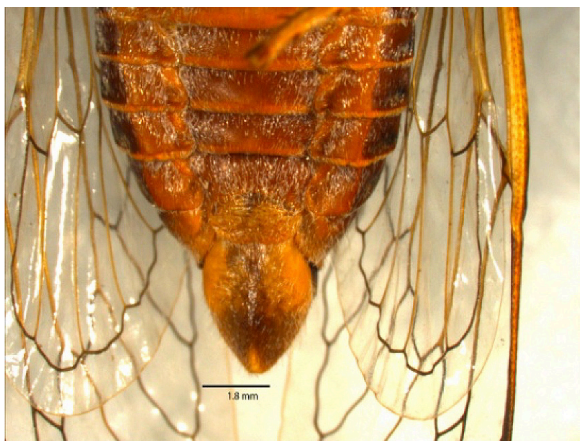

Figure 6. Male, sternites VII and VIII

collar produced middle of pronotum as triangular with two black figures. Mesonotum generally brownish with H shape in both sexes, both edge of mesonotum with a yellowish band. Scutal depression generally indistinct, surround of scutal depression blackish with dense setae; cruciform elevation yellowish in both sexes, sometimes brownish black in males also. Mesonotal posterior ridge near the wing groove yellowish brown in both sexes, sometimes blackish in males with dense setae (Figure 4).

Abdominal tergum blackish brown, sternum 1 in between of the timbals blackish, sometimes yellowish and others blackish brown with yellowish-brown markings in males, sternums yellowish brown in female.

Coxa and trochanter yellowish with blackish figure in basally, sometimes blackish-yellow. Front femora with two big, one small spine and brownish yellow sometimes blackish brown. Tibiae and tarsus generally blackish brown in both sexes, sometimes yellowish. Pretarsal claws basally brownish, claws apically brownish and basally yellowish. Opercula kidney-shaped, generally overlapping, broadly rounded, with sinuous yellow spine (meracanthus) (Figure 5). Sternite VIII yellow, longer than sternite VII. Between 3^{th}-6^{th} abdominal segments slightly forming a rounded ridge with yellowish band (Figure 6).

Figure 7. Female from lateral view

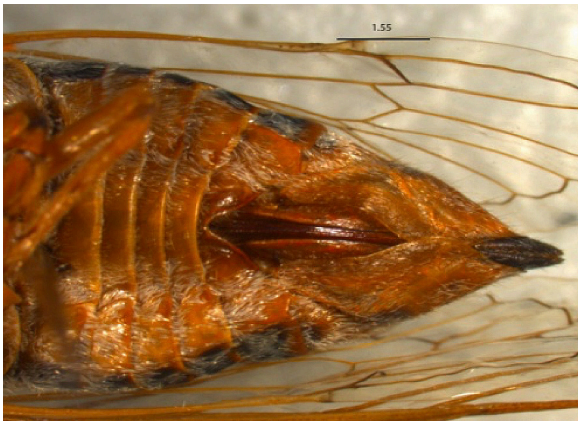

Figure 8. Female genitalia from ventrally (scale= 1.55 mm)

Tegmina and hind wings transparent, without markings, 2.45-2.9 times as long and as wide in male and 2.35-2.6 times in female. The numbers of apical cells on front wings are 7, and on hind wings, 6 in both sexes. Basal cell of the tegmina transparent, basal membrane yellowish to orange. The base of the costal cell with yellowish hind wings. Veins yellowish basally, brownish apically (Figure 7). Especially near the sutures of head, apical part of pronotum, paramedian and lateral fissure, behind of the eyes, gena, lorum, coxa, trochanter, femur, tibia, anepisternum, katepisternum, anepimeron, outside of abdominal sternum, and apical half of pygophore white dense setae.

Pygophore; dorsally blackish, ventrally yellowish; with one basal lobe and dorsal beak acute (Figure 6). Aedeagus C shape, dark brownish, with one short projection, one long spine and in subapically with spine mass. Median lobe of the uncus shorter than dorsal beak of pygophore, lateral process of uncus brownish, anal stile blackish and anal tube dorsally blackish, ventrally yellowish. Hypandrium yellowish-brown with dense spines. Its apical part wider than basal part, 1.4-1.6 times longer than its width; ovipositor length 6.2 mm (Figure 8). The overall coloration is yellowish black with brown, pale yellow and brown markings (Table 1).

Acoustics

References to song: Boulard 1995; 28, 29; Boulard et al. 2018

Calling song: Males of the *Cicadatra hyalina* make sounds by using the timbals. I was able to record the calling song clearly, which consists of continuous signal and echeme song (Figure 9, 12). Calling song lasts without interruption for some minutes and is made of a continuous signal (Fig 9). Duration of continuous song varies. Lasting, on average, 1.3-9 minutes or longer (Fig. 10). Continuous signal consists of regular syllables which are made of 5-6 pulses, lasting, on average, 5-6 ms (Fig.11). After some minutes, continuous signal change into a short echeme song, which is regulary repeated.

Echeme song (called rumbling sound by Boulard et al. 2018) lasting, on average, 1710 ms (Range 640-8952 ms; standart deviatin 651; samples 94) (Figure 13). Interval between echemes sound, on average, 431 ms (Range 232-704 ms; standart deviation 149; samples 74). Echemes consist of two connected pulses and last 2-3 ms and the interval between connected pulses last 14-16 ms (Figure 14).

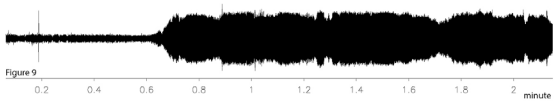

Figure 9. Calling song, continuous song

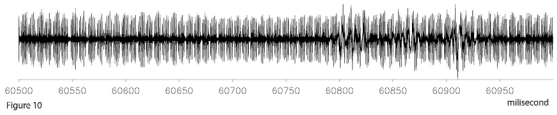

Figure 10. Calling song, continuous song, echeme phrase

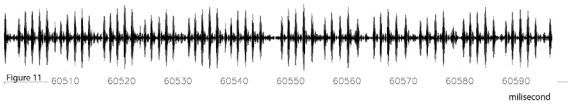

Figure 11. Syllables (12) and pulse

Frequency range: The spectrum of these acoustic signals include frequencies from about 10248 to 16760 Hz with a maximum of 10248, 11791 Hz and 15163 Hz, 16760 Hz.

Table 1. Means for 16 morphometric characteristic measured from five males and one female from Anatolian populations belonging to *Cicadatra hyalina* (Fabricius), (n=medim, N= specimens number)

Characters (for both sexes) mm	**Cicadatra hyalina (mm)**		
Tip of the crown from to apical margin of the right forewing		**Male**	**Female**
	Range	20-23	20-23
	n	22	22.2
	N	5	7
Wings length one tip from the other tip	Range	39-43	44-47
	n	41	45.4
	N	5	7
Body length (Tip of the crown from to tip of the abdomen)	Range	11.5-17.5	14.5-18
	n	17.2	16.6
	N	5	7
Medial length of crown	Range	1.45-1.65	1.6-2.0
	n	1.54	1.78
	N	5	7
Minimum distance between ocular stures	Range	2.6-2.8	2.4-2.8
	n	2.72	2.62
	N	5	7
Medial length of frons	Range	0.4-0.5	0.45-0.8
	n	0.46	0.7
	N	5	7
Medial length of pronotum	Range	1.9-2.2	2-2.32
	n	2.1	2.15
	N	5	7
Medial length of mesonotum	Range	3.8-4.4	4-4.8
	n	4.1	4.4
	N	5	7
Length of right forewing	Range	17.5-20	18-20
	n	18.7	18.75
	N	7	7
Width of right forewing	Range	6-8	7.5-8.0
	n	7.2	7.76
	N	7	7
Length of dorsal margin of the left fore femur	Range	2.3-2.6	2.4-3
	n	2.46	2.71
	N	5	7
Length of anterior margin of basal cell	Range	1.6-1.8	1.40-1.70
	n	1.71	1.48
	N	5	7
Distance from anterior right corner to posterior left corner of left operculum	Range	3-3.72	-
	n	3.3	
	N	5	
Length of pygofore in lateral view	Range	3.4-3.8	-
	n	3.5	
	N	5	
Aedeagus length	Range	2.5-2.8	-
	n	2.7	
	N	3	
Hypandrium length (male)/ Ovipositor length (female) mm	Range	3.6-4.0	5.3-6.5
	n	3.7	5.95
	N	4	7

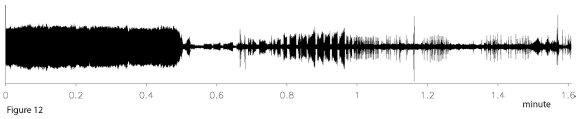

Figure 12. Calling song, continuous song and echeme song

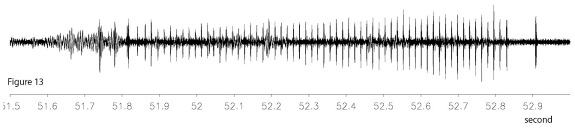

Figure 13. Calling song, 1 echeme (rumbling sounds)

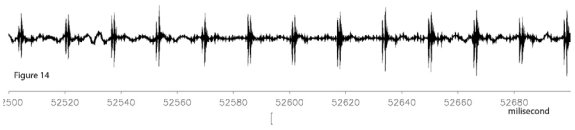

Figure 14. A part of one echeme, and two connected pulses and interval between connected pulses

Figure 15. Malatya, Doğanşehir, Çığlık, 1300 m, 2012 (Fotoğraf: Dr. Deniz ŞİRİN)

Specimens examined: ÇORUM: Mecitözü, Emirbağ village, 650 m, 3.vii.2012, 1 male; BAYBURT: Bayburt-Aşkale road, 30. km 1850 m, 15.07.2012, 1 male; BURDUR: Burdur-Isparta road, 20. km, 941 m, 9.vii.2014, 5 males, 6 female, Leg. A. MOL; BURSA: İznik, Ömerli Bağları, 7.viii.2005, 1 male; ELAZIĞ: Sivrice, Hazarbaba Sky Sentre, 3.vii.2012, 1785 m, 1 male; KAHRAMANMARAŞ: Saimbeyli-Göksun road, 09.vii.2015, 1454 m, 4 males, 1 female; MALATYA: Doğanşehir, Çığlık town, 04.vii.2012, 1300-1500 m, 2 males, 1 female; MUĞLA: Bodrum, Aspat, 18.vi.2006, 1 male; 1.viii.2008, 1 female, Leg. B. ELLE; NIĞDE: Çamardı, Üçkapular Mountain, 8.vii.2015, 1981 m, 1 male (Figure 1).

Figure 16. Niğde, Çamardı, Üçkapılar Mountain, 1981 m, 2015 (Fotoğraf: Dr. Deniz ŞİRİN)

DISCUSSION AND CONCLUSION

Cicadatra hyalina (Fabricius, 1798) is one of the most widespread Cicadas species distributed in Azerbaijan, Turkey, Balkan Peninsula, Armenia, South Russia, Georgia, Persian, Israel, Syria, Turkmenai, Ukrain, and Jordan (Boulard et al. 2018, Duffels and Laan 1985, Kartal and Zeybekoğlu 1999, Mozaffarian and Sanborn 2010, Nast 1972). According to Kaplan and Tezcan (2016), *C. hyalina* is recorded from Adıyaman, Ankara, Antalya, Elazığ, Erzincan, Gümüşhane, Hakkâri, Isparta, İzmir, Konya, Kahramanmaraş, Nevşehir, Niğde, Siirt, Şanlıurfa, and Van so far. In addition to these localities this species was collected from Bayburt, Burdur, Bursa, Çorum, Malatya, and Muğla provinces.

Dlabola (1981, 1987) indicated that species is known to reside in arboreal-pontomediterranean fauna element and it prefers half deserts with deciduous trees (Schedl 1999). In this study, *Cicadatra hyalina* (Fabricius) specimens were collected from herbaceous in Çorum, Bayburt, Elazığ, Kahramanmaraş, and Malatya but it was collected from scrub in Burdur and Niğde provinces (Figure 15, 16).

Cicadatra hyalina is related to *Cicadatra platyptera* (Olivier, 1790), but *C. hyalina* is different from *C. platyptera* especially in terms of male genitalia and calling song. *C. hyalina*, without upper lobe of pygofer (in *C. platyptera* with upper lobe of pygofer); *C. hyalina,* basal part of sternite VIII cambered (in *C. platyptera* basal part of sternite VIII triangular); *C. hyalina,* aedeagus curved before the apex (in *C. platyptera* not curved), *C. hyalina,* aedeagus without long spine in apically (*C. platyptera* aedeagus with three long spines in apically).

Figure 15. Malatya, Doğanşehir, Çığlık, 1300 m, 2012, Foto, Dr. Deniz ŞİRİN

Males of *Cicadatra hyalina* make sounds by using the timbals (*C. platyptera* used timbals and fore wings), males of *Cicadatra hyalina* produced calling song (*C. platyptera* produced calling song and courtship song), male calling song of *C. hyalina* consist of continouos song and echemes (*C. platyptera* consist of echemes) male calling song of *C. hyalina* without wing clicks (male calling song of *C. platyptera* with wing cliks) (Mol et al. 2013).

Figure 16. Niğde, Çamardı, Üçkapılar Mountain, 1981 m, 2015, Foto, Dr. Deniz ŞİRİN

There are differences between our recordings of frequencies and that of Boulard (1995). The frequencies calculated range from about 10248 to 16760 Hz and average at 11800 Hz, but Boulard (1995) reported that this species frequencies' range from 8300 to 12000 Hz and average at 1000 Hz. The average frequency of songs recorded during this study is about 2000 Hz higher than the frequencies of sounds recorded by Boulard (1995).

Kartal and Zeybekoğlu (1999) indicated that *C. hyalina* has variation in external genital structures, color and speckling of male. In this study, it was revealed that body colors of specimens collected from Bursa are nearly all blackish. In addition to that, in terms of body length, some differences were measured from literature. Such as in male body length, which measured 20-23 mm (19.70-22.00 mm in Kaplan and Tezcan 2016), in females, open wing 44-47 mm (38.80-44.80 mm in Kaplan and Tezcan 2016), and body length 14.5-18.00 mm (19-22 mm in Kaplan and Tezcan 2016).

Male calling song have not been studied elaborately so far, exceptions being Boulard (1995) and Boulard et al. 2018. That is why I can not compare literature, nor criticize. But according to my data echeme song differed from Boulard (1995). Namely, the echeme morphology of calling song was given crescendo by Boulard (1995) and Boulard et al. (2018). But some echemes consist of irregular syllable length in my records. I think that *Cicadatra* Kolenati, 1857 species of Turkey need to be revised.

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ÖZET

Bu çalışmada, özellikle nimf evresinde tarımsal ve ekili alanlara verdiği zararlar nedeniyle ekonomik önemi olan *Cicadatra hyalina* (Fabricius, 1798) türü, morfoloji, biyoakustik, varyasyon ve bazı ekolojik özellikleri bakımından araştırılmıştır. Önemli morfolojik özellikleri tanımlanan türe ait örneklerin özellikle renklenme bakımından bazı varyasyonları tespit edilmiştir. Erkek çağrı sesi sürekli ve guruldama şeklinde olmak üzere iki kısımdan oluşur. Sesin sürekli devam eden kısmı 1-3 dakika, guruldama şeklindeki kısım 1710 ms, guruldama şeklindeki seslerin arasındaki süre ise ortalama 450 ms'dir. Önceki kayıtlara ek olarak türe ait örnekler Bayburt, Burdur, Çorum ve Malatya illerinden de toplanmıştır. Çalışma şekillerle desteklenmiştir.

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