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***Chorthippus bornhalmi* in the heart of the Balkans (Acrididae: Gomphocerinae)**

Josip Skejo & Slobodan Ivković

Abstract

New records of *Chorthippus bornhalmi* in the Balkans are presented. The grasshopper is reported from 7 localities from the protected landscape of Vlasina in SE Serbia, representing the first records for Serbia. The new records of the species are discussed and bioacoustical information and general distribution is presented.

Zusammenfassung

Es werden neue Funde von *Chorthippus bornhalmi* auf dem Balkan gemeldet. Die Art wurde an sieben Stellen im montanen Schutzgebiet Vlasina im Südosten Serbiens gefunden, was gleichzeitig Erstdachweis für Serbien ist. Neben der Darstellung der Neufunde werden Informationen zur Stridulation und zur Gesamtverbreitung der Art gegeben.

Rezume

Predstavljani su novi nalazi vrste *Chorthippus bornhalmi* na Balkanu. Vrsta je nađena na 7 lokaliteta u predelu izuzetnih odlika Vlasina (JI Srbija). Raspravljani su novi nalazi vrste te su predstavljeni bioakustički podatci i opšta rasprostranjenost vrste. Ovo su prvi nalazi ove vrste za srpsku faunu.

Introduction

Balkan grasshopper (*Chorthippus bornhalmi*) (Caelifera: Acrididae: Gomphocerinae: Gomphocerini) is a grasshopper species described by HARZ in 1971 from the Dubrovnik area in S Croatia as a cryptic species very similar to *Chorthippus brunneus* (Thunberg, 1815). In the Balkans the only difference in morphology between these two species is the number of stridulatory pegs in the male (> 100 in *Ch. bornhalmi*; < 90 in *Ch. brunneus*) (e.g. HARZ 1975, WILLEMSE et al. 2009).

Both species are part of the *Chorthippus biguttulus* group (hereafter abbreviated to *biguttulus* group), that currently counts 25 taxa, 12 species, and 13 subspecies (ŞIRIN et al. 2010). Species from the genus *Chorthippus* characterized by angled pronotal keels are often placed within the subgenus (STOROZHENKO 2002) or even genus (MASSA et al. 2012) *Glyptobothrus* Chopard, 1951, but apart from the divergence of the lateral keels no strong synapomorphies were found hitherto (WILLEMSE et al. 2009).

Species within the *biguttulus* group are often difficult to identify on morphology alone, primarily because of the variability of certain characters and potential hybridization. It is more practical and more accurate to base the species identification on the male calling song (WILLEMSE et al. 2009).

The aim of our research was to record the distribution and song of *Ch. bornhalmi* in the protected landscape of Vlasina in SE Serbia, the population situated most inland in the Balkans. Furthermore the Orthoptera assemblages on these localities were documented.

Materials and methods

Study area

Vlasina is a mountainous region in SE Serbia. It is part of Rhodopian Serbia, bordering Bulgaria, with old rocks and mountains. On the plateau (1260 m a.s.l.), the reservoir of Vlasina is situated. The area is characterized by 150 springs, with a characteristic hygrophilous flora.

It is possible to distinguish four characteristic belts by elevation and plant community: (i) lowland (< 400 m a.s.l., with willow, poplar, ash and red oak forests), (ii) hilly (400-1000 m, with European hornbeam, Cornish oak, Turkey oak, Italian oak and pubescent oak), (iii) mountainous (1000-1400 m, with Norway spruce, silver fir, beech and black pine) and (iv) subalpine belt (> 1400 m, subalpine beech forests). Our fieldwork was restricted to the mountainous (iii) and subalpine belt (iv) (e.g. MARKOVIĆ 1990).

The study area is full of microhabitats, both wet and dry and thus is rather rich in fauna and flora. From July 14 to 19, 2014 we recorded *Ch. bornhalmi* on seven localities. All the localities are listed in the table 1 and shown on the map (Fig. 1).

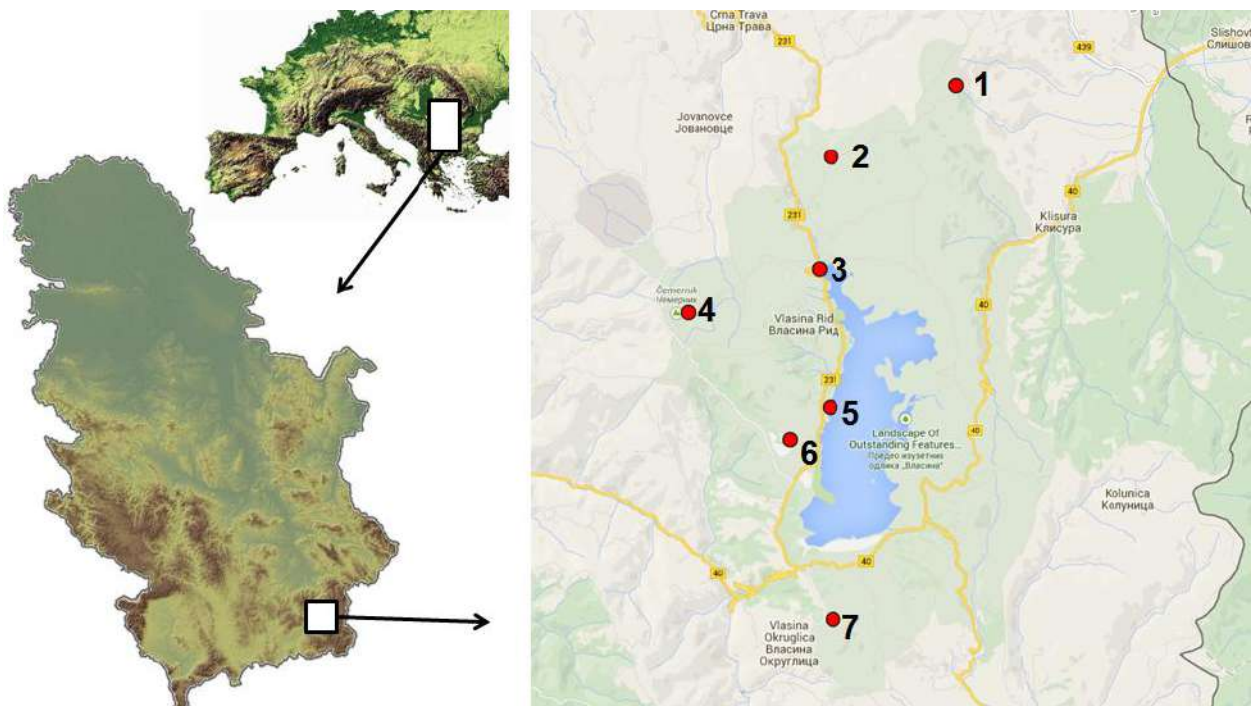


Figure 1: Map of the investigated area. Numbers of the localities follow the order given in the Table 1.

Table 1: List of the localities investigated in 2014 in Vlasina.

N	Locality	N Coord.	E Coord.	ELV/m	Description	Date
1	Vrtop	42.792908	22.37329	1690 – 1721	Subalpine meadow with low vegetation.	16.VII.
2	Polomska čuka	42.774564	22.32984	1430 – 1460	Fragments of mountainous grasslands near the beech and conifer forest.	17.VII.
3	N lake shore	42.745787	22.32562	1220 – 1240	Very wet, hygrophilous meadow by the lake.	14.VII.
4	Čemernik	42.734527	22.27959	1510 – 1595	Dry, low (and somewhat bushy) vegetation.	18.VII.
5	Ljote	42.710124	22.32937	1214 – 1218	Hygrophilous meadows by the lake with dry microhabitats which are not similar to the surroundings.	17.VII.
6	Paljina	42.701625	22.31526	1240 – 1320		17.VII.
7	Širine	42.655505	22.33044	1250 – 1560	Mesohygrophilous grasslands with low grass.	19.VII.

Sampling

The specimens were caught with an entomological net and by hand or observed in the field and photographed. We traced grasshoppers visually and acoustically. The specimens were preserved in a 69% ethanol solution or dry. All the material is deposited in the private collection of the first author in Zagreb. The identifications were checked by comparing with other material in the collection and by using following keys: HARZ (1975), WILLEMSE et al. (2009) and MASSA et al. (2012). We regard the key by WILLEMSE et al. (2009) as the most informative and reliable, because of the species variability and detailed description of the song.

Bioacoustics

The male calling song was recorded using Roland R-05 field sound stereo recorder. Oscillograms were generated in AviSoft-SASLab Pro (AviSoft Bioacoustics) and Cool Edit Pro 2.1. (Adobe Systems) software. The terminology follows WILLEMSE et al. (2009).

Results and discussion

During our field work in Vlasina we initially did not take *Ch. bornhalmi* into account, as it was not expected so far inland. After recording the calling song of a few males it became evident that *Ch. bornhalmi* was present (Fig. 3). The species was considered to inhabit only Mediterranean and Submediterranean types of habitats, but with some documented inland populations in the Balkans (CHOBANOV 2009a).

The calling song of *Ch. bornhalmi* from Vlasina is very similar to some Croatian Dinaric populations (Skejo, unpublished) and to that from Greece (WILLEMSE et al. 2009). The calling song is composed of a single echeme lasting more than 1.5 s (1.5-4.0 s). In most of the recorded specimens the echeme lasts less than 2 s. This is shorter than in other *Ch. bornhalmi* populations. This could imply gene flow between *Ch. brunneus* in the central Balkans with *Ch. bornhalmi*.

Occasionally, a second – very quiet and very short – echeme can occur. The echeme is characterised by a fast crescendo, with a quiet first part (1/6-1/3 of the song duration) and a louder second part (2/3-5/6 of the song duration). During the second part the echeme remains equally loud (Fig. 2A). The calling song of *Ch. brunneus* is the same as observed in the northern Serbia (Zasavica) (Skejo, unpublished) and very similar to *Ch. brunneus* of the Balkans (e.g. from Montenegro, INGRISCH & PAVIĆEVIĆ 2012). The song consists of a larger number of echemes than the song of *Ch. bornhalmi* (usually more than 5), which are much shorter (every echeme lasts for about 200 ms). The first and the last syllables are more quiet than the intermediate (Fig. 2B).



Figure 2: Oscillograms of A) *Ch. bornhalmi* and B) *Ch. brunneus*. Temperature of both recordings was 23.8 °C. Scale is 200 ms.



Figure 3: Bornhalm's grasshopper (*Chorthippus bornhalmi*), Vrtop, 16.VII.2014.
Photo J. Skejo.

We recorded *Chorthippus bornhalmi* on seven localities in the protected landscape of Vlasina (Table 1., Fig. 1). The Orthoptera communities were quite rich in these habitats (Table 2). The identification of the *Poecilimon* species from the *affinis* species group is still not definite, thus, they are listed with *confer* (cf.).

Table 2: List of the species recorded on the localities inhabited by *Ch. bornhalmi*. Locality numbers follow those presented in Table 1.

N	Genus species Author, year	1	2	3	4	5	6	7
suborder Ensifera								
family Gryllidae								
1	<i>Gryllus campestris</i> Linné, 1758		+		+	+	+	+
family Phaneropteridae								
2	<i>Isophya modestior</i> Brunner von Wattenwyl, 1882			+				
3	<i>Isophya bureschi</i> Peshev, 1959			+	+			+
4	<i>Poecilimon thoracicus</i> (Fieber, 1853)			+	+			+
5	<i>Poecilimon fussii</i> Fieber, 1878							+
6	<i>Poecilimon</i> cf. <i>affinis</i> (Frivaldszky, 1868)		+	+	+		+	+
7	<i>Polysarcus denticauda</i> (Charpentier, 1825)				+			
family Tettigoniidae								
8	<i>Conocephalus fuscus</i> (Fabricus, 1793)			+		+		+
9	<i>Ephippiger ephippiger</i> (Fiebig, 1784)			+			+	+
10	<i>Pholidoptera aptera</i> (Fabricus, 1793)				+			
11	<i>Pholidoptera fallax</i> (Fischer, 1853)			+			+	+
12	<i>Pholidoptera frivaldszkyi</i> (Herman, 1871)			+	+		+	+
13	<i>Bicolorana bicolor</i> (Philippi, 1830)		+	+	+		+	
14	<i>Roeseliana roeselii</i> (Hagenbach, 1822)		+			+	+	+
15	<i>Broughtonia domogledi</i> (Brunner von Wattenwyl, 1882)		+					+
16	<i>Decticus verrucivorus</i> (Linné, 1758)				+		+	
17	<i>Psorodonotus fieberi</i> Frivaldszky in Fieber, 1853	+	+		+			+
18	<i>Tettigonia viridissima</i> (Linné, 1758)			+	+	+	+	+
suborder Caelifera								
family Tetrigidae								
1	<i>Tetrix subulata</i> (Linné, 1758)			+		+		
2	<i>Tetrix bolivari</i> Saulcy, 1901			+				
3	<i>Tetrix tenuicornis</i> (Sahlberg, 1891)			+				
4	<i>Tetrix bipunctata</i> (Linné, 1758)			+		+		
family Acrididae								
5	<i>Psophus stridulus</i> (Linné, 1758)				+			
6	<i>Arcyptera fusca</i> (Pallas, 1773)				+			+
7	<i>Stenobothrus lineatus</i> (Panzer, 1796)		+		+	+	+	+
8	<i>Stenobothrus stigmaticus faberi</i> Harz, 1975				+			
9	<i>Myrmeleotettix maculatus</i> (Thunberg, 1815)	+			+	+		+
10	<i>Omocestus rufipes</i> (Zetterstedt, 1821)						+	+
11	<i>Omocestus viridulus</i> (Linné, 1758)		+		+			
12	<i>Omocestus haemorrhoidalis</i> (Charpentier, 1825)						+	
13	<i>Stauroderus scalaris</i> (Fischer von Waldheim, 1846)		+		+	+	+	
14	<i>Chorthippus dorsatus</i> (Zetterstedt, 1821)		+		+	+	+	
15	<i>Chorthippus brunneus</i> (Thunberg, 1815)	+	+	+	+			
16	<i>Chorthippus bornhalmi</i> Harz, 1971	+	+	+	+	+	+	+
17	<i>Chorthippus parallelus</i> (Zetterstedt, 1821)		+			+		
18	<i>Gomphocerus sibiricus</i> (Linnaeus, 1767)	+						
19	<i>Euthystira brachyptera</i> (Ocskay, 1826)		+	+	+	+	+	+
20	<i>Chrysochraon dispar</i> (Germar, 1834)			+	+	+	+	+
21	<i>Pseudopodisma fieberi</i> (Scudder, 1897)							+
Σ	18 (Ensifera) + 21 (Caelifera) = 39 species	5	12	20	23	14	17	21

The Vrtop peak is the most species poor locality, with only a few (5) species: one species of Ensifera (*Psorodonotus fieberi*) and 4 species of Caelifera (*Myrmeleotettix maculatus*, *Chorthippus brunneus*, *Ch. bornhalmi* and *Gomphocerus sibiricus*). *Ch. bornhalmi* was found in very large numbers in this habitat, together with *G. sibiricus*, while *M. maculatus*, *Ch. brunneus* and *Ps. fieberi* were recorded in significantly smaller numbers (<5 individuals per 20 meters transect).

On Polomska Čuka (12) and Ljote (14), short-horned grasshoppers were more diverse than long-horned grasshoppers, primarily because of the habitat types with open grasslands, which is favoured by pratinicole and graminicole Caeliferan species. We would like to highlight the occurrence of *Chrysochraon dispar*, one of the few known localities in Serbia (SKEJO & STANKOVIĆ 2014).

The shore of the north lake (20), Čemernik (23), Paljina (17) and Širine (21) are localities with rich Orthoptera communities. On these localities there are meadows with low vegetation, forest edges with bushy vegetation and light and dark forests, habitats favoured by a diverse spectrum of species. Important species are *Isophya bureschi*, *Broughtonia domogledi*, *Psorodonotus fieberi*, *Omocestus viridulus* and *Pseudopodisma fieberi*, which will be discussed in a more extensive faunistical paper on the Orthoptera of Vlasina.

Distribution and hybridization



Figure 4: Distribution map of *Chorthippus bornhalmi*.

Bornhalm's grasshopper is known from Italy (MASSA et al. 2012), Slovenia (GOMBOC & ŠEGULA 2014), Croatia (Harz 1971, 1975, Skejo, Rebrina & Tvrtković unpubl.),

Montenegro (INGRISCH & PAVIĆEVIĆ 2012), Albania (Puskás unpubl.), Republic of Macedonia (CHOBANOV & MIHAJLOVA 2010), Serbia (this study), Bulgaria (POPOV & CHOBANOV 2004, POPOV 2007, CHOBANOV 2009a, 2009b), Greece (WILLEMSE et al. 2009), Cyprus (TUMBRINCK 2006) and Turkey (ŞIRIN et al. 2010, SEVGILI et al. 2011, SEVGILI et al. 2012, MOL & ZEYBEKOĞLU 2013). The distribution map of the species is shown in Figure 4.

A hybrid zone between *Ch. brunneus* and *Ch. bornhalmi* is recorded in the region of Trieste in Italy (KLEUKERS et al. 2004), in Friuli (Fontana, Kleukers & Willemse pers. comm.) and in Croatia in Krka NP, Lika and Dinara Mt. (Skejo, unpubl.). It seems that hybridization occurs in the regions where none of the two species dominate, *id est* not in the population core. The first author did not record hybridization on the places with syntopical occurrence of both species where one species dominates. It could be due to easier male-female recognition and interaction if one species is more abundant. Also, according to the song characters, different grades of hybridization can be identified in different populations, some of the individuals more similar to *Ch. brunneus*, some more to *Ch. bornhalmi*. This implies constant gene flow between the two species. Species from the *biguttulus* group are very similar in morphology, sometimes song and they are not easily differentiated at the molecular level (VEDENINA & MUGUE 2011). There are many examples of hybridization within the *biguttulus* group (e.g. *Ch. brunneus* x *Ch. jacobsi*, *Ch. biguttulus* x *Ch. brunneus*, *Ch. eisentrauti* x *Ch. brunneus*) (GOTTSCHEBERGER 2007).

The *biguttulus* group is very young and the speciation between taxa is still in progress, resulting in a lot of populations with intermediate characters, as it has been observed in e.g. Italy, Croatia and Greece (KLEUKERS et al. 2004, WILLEMSE et al. 2009, Skejo unpubl.).

NIKČEVIĆ's (e.g. 2006, 2007, 2008) identification of *Ch. brunneus* from the karstic region of Montenegro is doubtful, as well as some other records that are to be attributed to misidentification, more than to exceptional biogeographic records (e.g. doubtful records of *Conocephalus conocephalus*, *Chorthippus albomarginatus* and *Acrida turrita* – none of these species being present in Montenegro). These records have to be reviewed.

From the North and East Adriatic coast to Greece (including Greece and probably European part of the Turkey from where there are no published data for the species) *Chorthippus bornhalmi* inhabits habitats of the Mediterranean and Submediterranean region, occurring occasionally in continental habitats. The species is present from sea level to more than 1900 m a.s.l. (WILLEMSE et al. 2009, INGRISCH & PAVIĆEVIĆ 2012, SKEJO unpubl.).

In this paper *Chorthippus bornhalmi* is reported for the first time in Serbia. This is not unexpected since the species has been reported from neighbouring Bulgaria very close to the Vlasina plateau in similar habitats (CHOBANOV 2009a). Further investigations are necessary to define the northernmost part of the range in the central Balkans, as well as to characterize hybrid zone and range border of *Chorthippus brunneus* in the Balkans. This paper provides information on general distribution of *Ch. bornhalmi* and a literature overview of the species distribution.

Also, the paper provides information for species discrimination in the field and is aimed to serve as a base for new research. Hybrid zones are to be investigated in detail in the future and we appeal for young and interested students, as well as amateurs interested in Orthoptera to make their contributions on this issue in the future by collecting specimens for morphological characterization and song recording.

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The idea for this publication was conceived by the second author. The paper was written by the first author. The Ensifera material was examined primarily by the second author, the Caelifera material by the first author.

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