The distribution and population numbers of Corncrakes *Crex crex* in the karst poljes of Bosnia-Herzegovina – results of a large-scale survey in 2012 and 2013

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Summary

Extensive wetlands and traditionally used grassland habitats in the karst poljes of Bosnia-Herzegovina are expected to harbour viable Corncrake populations. In 2012 and 2013, night-time surveys of calling males were conducted in 44 of the country's 57 karst poljes between late May and early July. In both years 62% - 64% (969.7 km^2) and 84% - 86% (1,308.1 km^2) of the total surface area of karst poljes in Bosnia-Herzegovina were investigated. Corncrakes were present in 29 poljes (66%) located between 58 m (Rastoka i Ljubuško polje) and 1,186 m a.s.l. (Kruško polje). With the numbers of calling males ranging from 0.1 – 6.1 males/km^2, the largest population (141 – 192 territorial males) was found in Livanjsko polje (408.0 km^2), the world's largest karst polje. Poljes with large-scale periodical flooding harboured 97% - 99% of the overall Corncrake population. In relation to surface (≈ survey) areas of individual poljes, exceptionally high numbers of ≥ 2.1 calling males/km^2 were observed in Šuičko, Lukavačko, Pašića and Lušci polje. As a result of highly differentiated flood water-levels, seasons, flood duration and vegetation type, no differences between breeding densities for poljes with maximum flood surfaces covering < 1% of the polje's total surface area and karst poljes with large-scale periodical flooding were found. Poljes harbouring large Corncrake numbers were characterized by extensive wet Molinion and Deschampsion meadows, pronounced gradients between wet and dry grasslands, and small-scale mosaics of meadows and arable fields. Based on the present survey, the total population for the karst poljes in Bosnia-Herzegovina is estimated at 480 – 790 calling males, while in the uplands of the Dinaric Karst smaller and more scattered populations exist in mountain and subalpine grassland habitats up to 1,468 m a.s.l. Although overall population numbers may exceed current estimates of 500 – 800 males for Bosnia-Herzegovina, the numbers of calling males have declined by 40% - 55% in Livanjsko polje compared to earlier counts in 2007 and 2009. The cumulative impacts of further alteration of the hydrological regimes of karst poljes through hydropower development in the drainage area of the upper Cetina River and the realization of the "Upper Horizons" hydropower project in the Neretva River basin will affect 28% - 47% of the current Corncrake population. In the near future breeding habitats will be further lost through natural succession in former war-zones which currently harbour substantial Corncrake numbers.

Sažetak

Smatra se da se u močvarnim područjima i ekstenzivno korištenim travnjačkim staništima kraških polja Bosne i Hercegovine nalazi znatna populacija kosca. 2012. i 2013. godine je urađeno brojanje glasajućih mužjaka na 44 od ukupno 57 kraških polja Bosne i Hercegovine. Istraživanje je vršeno tokom noći, u periodu između kraja maja i početka jula. 2012 godine istraženo je 62 - 64% (969.7 km^2), a 2013 84 - 86% (1,308.1 km^2) ukupne površine kraških polja u Bosni i Hercegovini. Kosac je zabilježen na 29 (66%) polja, na nadmorskoj visini od 58 (Rastoka i Ljubuško polje) do 1,186 metara (Kruško polje). Broj glasajućih mužjaka varirao je između 0.1 – 6.1 po km^2, a najveća populacija od 141, odnosno 192 zabilježena je u Livanjskom polju (408.0 km^2), najvećem plavnom kraškom polju na svijetu. Prilikom ovih istraživanja, 97 - 99% populacije kosca zabilježeno je poljima koja većim dijelom plave. U odnosu na površinu polja, posebno velika gustina populacije (≥ 2.1 glasajućih mužjaka/km^2) zabilježena je na Šuičkom, Lukavačkom, Pašića polju i Lušci polju. Međutim, nije zabilježena značajna razlika u gustini populacije na poljima na kojima poplave prekrivaju manje od 1% ukupne površine

i poljima koja plave većim dijelom, zbog različitih nivoa podzemne vode, dužine trajanja poplava i tipa vegetacije. Polja na kojima je zabilježena najveća brojnost kosca su prekrivena ekstenzivno korištenim vlažnim livadama na kojima dominiraju sveze Molinion i Deschampsion, mješovitim livadama na kojima je jasno naglašena razlika između vlažnih i suhih regiona i obradivim površinama. Na osnovu ovih istraživanja, ukupna populacija kosca na kraškim poljima Bosne i Hercegovine procijenjena je na 480, odnosno 790 glasajućih mužjaka, ali su zabilježene i manje populacije na planinskim i vlažnim travnjačkim staništima na nadmorskoj visini do 1,468 m. Iako postoji mogućnost da je ukupna populacija kosca u Bosni i Hercegovini veća od trenutne procjene, koja iznosi 500, odnosno 800 mužjaka, brojnost glasajućih mužjaka u Livanjskom polju se smanjila za 40 - 55% u odnosu na ranija prebrojavanja iz 2007. i 2009. godine. Izmjena vodnog režima kraških polja do koje će dovesti konstrukcija hidroelektrana u gornjem toku rijeke Cetine i realizacija projekta "Gornji horizonti" u slivu rijeke Neretve imat će negativan uticaj na 27 - 47% populacije ove vrste. U bliskoj budućnosti će zbog prirodne sukcesije doći do gubitka adekvatnih staništa u nekadašnjih ratnim zonama, na kojima se trenutno nalazi znatan broj kosaca.

Keywords: Corncrake, *Crex crex*, distribution, altitudinal distribution, karst poljes, population numbers, Bosnia-Herzegovina, Dinaric Karst

1. Introduction

In the Dinaric Karst fertile soils are largely restricted to karst poljes, flat-bottomed lands of closed depressions within karst limestone. The karst poljes of the Dinaric Alps, which range in size from a few ten hectares up to more then 400 km^2, harbour a number of significant wetlands and extensive grassland habitats. While in the wake of the last wars in Croatia and Bosnia-Herzegovina (1991-1995) extensive former war-zones were abandoned by local people, in many karst poljes agricultural production is based on traditional farming, such as growing fodder and the grazing of cattle, sheep and other domestic animals (Barać *et al.* 2011). Consequently, following to low human population and largely intact ecosystems, many karst poljes in Bosnia-Herzegovina are expected to harbour substantial numbers of water- and farmland birds. Besides high waterbird abundance in winter and during migration (Stumberger & Sackl 2008/09, Stumberger & Schneider-Jacoby 2013), a first assessment of the bird fauna of Livanjsko polje and other karst poljes in the catchment area of the upper Cetina River indicated significant populations of breeding farmland birds, like Common Quail *Coturnix coturnix*, Corn Bunting *Miliaria calandra*, Yellow Wagtail *Motacilla flava cinereocapilla, M. f. feldegg,* Red-backed *Lanius collurio* and Lesser Grey Shrike *L. minor* (Schneider-Jacoby *et al.* 2006, Ozimec *et al.* 2013).

Corncrakes *Crex crex* inhabit at least 20 – 30 cm tall vegetation of open and semi-open, extensively managed grasslands which provide cover and plenty of food. In the primeval landscapes of Europe lowland marshes, mosaic-like patchworks of floodplain habitats and riverine meadows presumably constituted their predominant habitats (Flade 1991, 1997, Green *et al.* 1997). Although Corncrakes are found in drier habitats then most other rails (Rallidae), they require regular flooding and react to changes in the hydrological regime of grasslands and intensification of grassland management (Trontelj 1994, 1997, Green *et al.* 1997, Schäffer & Green 1997, Schäffer 1999, Schäffer & Koffijberg 2004).

According to its dependence on extensive wet grassland habitats, Schneider-Jacoby (1991) stressed the importance of the floodplains in the lowlands of the Sava and Danube rivers for the species in a first review of the distribution and population numbers in former Yugoslavia (cf. Antal *et al.* 1971). Following to scattered museum specimens and occasional reports he further addressed the necessity for systematic surveys and counts of periodically flooded karst poljes in Slovenia, Croatia, Bosnia-Herzegovina and Montenegro (Schneider-Jacoby 1991, Trontelj 1994, 1997). In particular, estimates of > 200 - 1000 calling males for Livanjsko polje, the world's largest karst polje, observed until 1991 (Schneider-Jacoby 1991, Radović & Dumbović 2001), indicated that the karst poljes of the Dinarides may harbour viable Corncrake populations.

While, up to now, most karst poljes remained unexplored, 314 and 315 calling males were found during first total counts in Livanjsko polje in 2007 and 2009, respectively (Stumberger *et al.* 2010). Except of an additional survey of Vukovsko polje in western Bosnia, consecutive counts remained occasional. However, based on these data, Kotrošan *et al.* (2012) estimated the current population in Bosnia-Herzegovina at 500 – 800 calling males. Because of their role as suitable bioindicators for grassland

biodiversity and management (Trontelj 1997, Wettstein & Szép 2003, Schäffer & Koffijberg 2004) systematic Corncrake surveys covering almost all periodically flooded karst poljes in Bosnia - Herzegovina were conducted within the framework of a EuroNatur project for the conservation and sustainable use of the karst environments in the Dinaric Alps in summer 2012 and 2013. The present paper also includes a concise review of historic Corncrake records in Bosnia-Herzegovina compiled from collected specimens, as well as from published and unpublished sources which served as background information for the recent surveys.

2. Study area

The continuous Dinaric Karst of the Western Balkans occupies a total area of approximately 70,400 km² between Slovenia and Albania (Božičević 1992) and harbours about 140 karst poljes (3,056 km²). Two thirds of the poljes are

Tab. 1: Location, total area, maximum and potential flood surface of karst poljes surveyed in Bosnia-Herzegovina, 2012 and 2013, according to Stumberger (2010) and Schwarz (2013). FBH = Federation of Bosnia and Herzegovina, RS = Republika Srpska.

Karst polje	Administration	Altitude (m a.s.l.)	Total area (km²)	Max. flood surface (km²)	Pot. flood surface (km²)	Coverage	
						2012	2013
Kruško polje	Livno, FBH	1186	3.6	0	0	-	total
Vukovsko polje	Kupres, FBH	1160	28.1	0.4	0.4	total	total
Ravna Mliništa	Glamoč, FBH	1157	4.4	0.2	0.2	-	total
Ravanjsko polje	Kupres, FBH	1131	19.2	0	0	-	total
Kupreško polje	Kupres, FBH	1115	81.2	36.2	43.8	< 90%	< 90%
Borovo polje	Livno, FBH	1102	4.0	0	0	-	total
Slato polje	Nevesinje, RS	1012	4.1	0.7	0.7	total	total
Vučipolje	Posušje, FBH	977	1.1	0	0	-	total
Gatačko polje	Gacko, RS	936	60.1	38.2	42.9	total	< 90%
Šuičko polje	Tomislavgrad, FBH	914	2.7	1.5	1.5	total	total
Roško polje	Tomislavgrad, FBH	894	3.9	0.1	0.1	< 90%	-
Rakitno	Posušje, FBH	890	14.1	5.1	5.1	-	total
Glamočko polje	Glamoč, FBH	883	62.4	47.2	47.2	< 90%	< 90%
Carevo polje	Trebinje, RS	875	0.3	0	0	-	total
Duvanjsko polje	Tomislavgrad, FBH	865	125.0	53.1	78.5	total	< 90%
Lukavačko polje	Nevesinje, RS	865	3.3	0.6	0.6	total	total
Konjsko polje	Trebinje, RS	829	1.4	0	0	-	total
Nevesinjsko polje	Nevesinje, RS	829	77.5	16.6	16.6	-	< 90%
Cernica	Gacko, RS	816	5.5	1.9	1.9	total	total
Pašića polje	Bosansko Grahovo, FBH	792	13.6	5.8	5.8	total	total
Marinkovci	Bosansko Grahovo, FBH	788	10.1	0	0	-	total
Grahovsko polje	Bosansko Grahovo, FBH	782	23.0	1.7	4.1	< 90%	total
Dugo polje	Bosanski Petrovac, FBH	776	2.5	0	0.4	-	total
Podrašničko polje	Mrkonjić Grad, RS	729	34.2	12.7	12.7	total	total
Livanjsko polje	Livno, Tomislavgrad & Bosansko Grahovo, FBH	702	408.0	274.5	307.3	total	total
Petrovačko polje	Bosanski Petrovac, FBH	637	22.4	3.5	3.5	total	total
Medeno polje	Bosanski Petrovac, FBH	602	5.7	0	1.7	-	total
Bjelajsko polje	Bosanski Petrovac, FBH	578	9.4	0	3.6	-	total
Posušje	Posušje, FBH	578	21.7	5.1	5.1	-	< 90%
Ljubomir polje	Trebinje, RS	506	12.7	1.3	1.3	-	total
Dabarsko polje	Berkovići, RS	472	28.9	16.7	22.3	total	total
Fatničko polje	Bileća, RS	452	7.7	7.3	7.3	total	total
Ljubinjsko polje	Ljubinje, RS	396	6.9	0.9	0.9	-	total
Palanka (Lušci polje)	Sanski Most, FBH	380	22.7	7.4	7.4	total	total
Kočerinsko polje	Grude & Široki Brijeg, FBH	302	4.9	2.5	2.5	-	total
Mokro polje (Trebinje)	Trebinje, RS	269	6.2	3.0	4.2	-	total
Mokro polje (Široki Brijeg)	Široki Brijeg, FBH	260	2.8	0.7	0.7	-	total
Imotsko (Bekijsko) polje	Grude, FBH	251	87.4	3.9	8.8	-	< 90%
Popovo polje	Trebinje, RS & Ravno, FBH	227	118.9	42.1	77.8	< 90%	total
Mostarsko blato	Mostar, FBH	223	33.1	31.8	33.1	-	total
Crničko polje	Stolac, FBH	212	2.9	0	1.2	-	total
Gradac	Neum, FBH	88	2.2	0	0.1	-	total
Rastoka i Ljubuško polje	Ljubuški, FBH	58	74.5	12.7	12.7	-	total
Hutovo blato[1]	Čapljina, FBH	2	32.7	32.7	32.7	total	total

[1] According to Schwarz (2014), surface area, maximum and potential flooded surface 39.7 km², respectively

rarely or frequently flooded (Stumberger 2010). In general, the Dinaric Karst's poljes are flooded during the wet and cold periods of the year between October and April, while in spring and summer, due to low precipitation, water-levels slowly recede (Bonacci 1987). Flood duration and flood water-levels in the poljes fluctuate between several days and six months, and from < 1 m up to 40 m, respectively (Bonacci 1987, Milanović 2003). According to Stumberger (2010), the overall surface area of 57 karst poljes, identified in Bosnia-Herzegovina, amounts to 1,550.5 km^2. An evaluation of Schwarz (2013) revealed a total area of 1,525.7 km^2, based on elevation models and remote sensing data (ASTER 2). Schwarz (2013) estimated 37 poljes (675.1 km^2) to be periodically flooded and the overall potential for flooding amounting to 802.6 km^2. In Bosnia-Herzegovina, harbouring some of the best preserved poljes of the region, karst poljes are situated in altitudes between 2 m (Hutovo blato) up to 1206 m a.s.l. (Dugo polje/Dugorudo).

For the present study 44 poljes between 2 and 1187 m a.s.l. were investigated. In total, the survey area amounted to 1,435.8 km^2, i.e. 93% – 94% of the total surface area of karst poljes in Bosnia-Herzegovina, with the surface area of individual poljes ranging from 0.3 – 408.0 km^2 (Stumberger 2010, Schwarz 2013). A third of all poljes, covering 55% of the total survey area, is situated in the altitudinal belt between 700 and 900 meters a.s.l. (Tab. 1). For the present study 13 poljes covering a total area of 53.5 km^2 were not visited. Aside from Dugo polje (Dugorudo) with a surface area of 19.1 km² the latter include predominantly dry poljes (*fossil karst poljes*) with smaller surface areas between 0.5 – 9.6 km^2. In 2012 a total area of 969.7 km^2 (62% - 64%) was investigated, while in 2013 the survey area covered 1,308.1 km^2 (84% - 86% of the total surface area of karst poljes in Bosnia-Herzegovina) (Tab. 3). While most counts covered the whole surface area of the poljes, some extensive former war-zones remained inaccessible due to land mines. Consequently, some karst poljes which lack safe access roads and tracks were only partially counted (cf. Tab. 3).

3. Methods

Calling males were counted during night-time surveys from fixed observation points along paved roads and tracks between 22:00 h and 3:00 h. With a maximum distance of 1,500 m, observation points were, as far as possible, distributed in that way that the whole surface area of the poljes was intercepted. At all observation points a minimum of 5 minutes were spent to locate spontaneously calling males. Besides on the surface area, the number of observation points depended on the accessibility of the poljes (s. 2. Study area), and varied between two for the smallest site (Carevo polje) and 152 observation points for the largest polje (Livanjsko polje). Playbacks of male territorial calls were only occasionally applied during cold weather or at points where no spontaneously calling males were present. In no case Corncrakes responded to playbacks. A minimum of two simultaneously calling males were considered as a single calling group (cf. Schäffer 1994, Schäffer & Koffijberg 2004). Due to the open and flat bottoms of the karst poljes which provide optimal sound propagation and with many poljes being largely undisturbed by artificial noise, groups separated by a distance of ≥ 3 km were defined as different calling groups. Group size was calculated for counts where observation points and calling males were located on the spot with the mapping method (n = 30). 2012 censuses were conducted by 9 observers between 4 and 27 June, while the census in 2013 was supported by 15 field observers from 31 May - 3 July. Although at least two counts per season are recommended for Corncrakes (Schäffer 1994, Gilbert *et al.* 1998), two consecutive visits of the poljes were not possible for the present survey in the same year.

4. Results

4.1 Historic records

Apart from the present study, 84 unpublished and published records of Corncrakes are known within the current borders of Bosnia-Herzegovina. With the first written report dated back to 1847 when the species was heard in riverine meadows near Fojnica in central Bosnia during the late 19th and early 20th centuries, almost all records represent observations and collected specimens listed in Othmar Reiser's (1861 – 1936) unpublished inventory *Ornitologica balcanica II* in the National Museum of Bosnia-Herzegovina in Sarajevo and the first volume of his monumental work *Materialien zu einer Ornis Balcanica* (1939). Following to a revision in 2000, all specimens (6 ♂♂, 2 ♀♀) are still kept in the National Museum in Sarajevo (Tab. 2).

Tab. 2: Corncrake records in Bosnia-Herzegovina, 1847 – 2013. C = central, SE = south-east etc.; Ornitologica balcanica = unpublished inventory of O. Reiser in the National Museum of Bosnia-Herzegovina, Sarajevo.

Locality/region	Altitude (m)	Date	Numbers	References/sources
Fojnica, C Bosnia	762	1847	calling (spring)	Reiser (1939)
Sarajevsko polje, C Bosnia	505	Sept. 1888	1 ♂, leg. O. Reiser	Ornitologica balcanica
Hutovo blato, Herzegovina	2	9.10.1888	2 ind. (migration), leg. O. Reiser	Ornitologica balcanica, Reiser (1939)
Sarajevsko polje, C Bosnia	504	27.9.1890	7 ind. migration (1 ind., leg. O. Reiser)	Reiser (1939)
Trebević, C Bosnia	1300	29.9.1890	1 ind., leg. O. Reiser	Reiser (1939)
Čengiv Vila, Novo Sarajevo, C Bosnia	596	1.12.1890	1 ♂, leg. O. Reiser	Ornitologia balcanica, Obratil (1975)
Reljevo, C Bosnia	485	8.12.1890	1 ind.	Reiser (1939)
Vrngorač, W Bosnia	162	8.7.1891	1 calling	Reiser (1939), Obratil (1975)
Blažaj, Sarajevsko polje, C Bosnia	495	8.11.1891	1 ♀, leg. J. Knotek	Reiser (1939)
Matrag, Glamoč; W Bosnia	1277	25.8.1897	1 calling	Reiser (1939)
Bosanska Gradiška, Posavina	95	12.10.1897	'first migrating birds'	Reiser & Knotek (1901), Obratil (1975)
Bosanska Gradiška, Posavina	95	26.10.1897	'last migrating birds'	Reiser & Knotek (1901), Obratil (1975)
Ključ, W Bosnia	260	1.11.1897	2 ♂♂ (migrantion)	Reiser & Knotek (1901), Obratil (1975)
Ključ, W Bosnia	260	15.12.1897	1 ♀ (migration)	Reiser & Knotek (1901), Obratil (1975)
Sarajevo, C Bosnia	537	16.9.1897	several migrating ind.	Reiser & Knotek (1901)
Sarajevsko polje, C Bosnia	504	25.8.1899	unusually strong migration	Reiser (1939), Obratil (1975)
Sarajevsko polje, C Bosnia	505	19.9.1899	1 ind. (migration), leg. O. Reiser	Ornitologica balcanica
Koševo, Sarajevo, C Bosnia	560	15.10.1900	1 ind. (migration)	Reiser & Knotek (1901)
Doboja - Usore, C Bosnia	165	14.5.1904	1 calling	Reiser (1939)
Sarajevsko polje, C Bosnia	489	19.8.1906	1 juv. ♂, leg. J. Baier	Ornitologica balcanica
Orahovo na Savi, Posavina	82	30.8.1906	several ind. (possibly migrants)	Reiser (1939), Obratil (1975)
Vozuča na Krivaji, C Bosnia	275	21.10.1906	1 ♂, leg. O. Reiser	Ornitologica balcanica, Reiser (1939)
Orašje, Posavina	83	28.6.1911	here and there calling	Reiser (1939), Obratil (1975)
Jablanica, Maglaj na Bosni, C Bosnia	186	26.6.1918	many calling	Reiser (1939)
Donja Paklenica, Maglaj na Bosni, C Bosnia	159	26.6.1918	many calling	Reiser (1939)
Bardača, Posavina	88	June 1970	species present	Obratil (1983)
Bardača, Posavina	88	June 1971	species present	Obratil (1983)
Bardača, Posavina	88	June 1972	species present	Obratil (1983)
Bardača, Posavina	88	June 1973	species present	Obratil (1983)
Svilaj - Bosanski Šamac, S Bosnia	86	1970s/80s (unknown date)	species present	Obratil (1999)
Tjentište, SE Bosnia	560	1970s/80s (unknown date)	species present	Rucner & Obratil (1973), Obratil (1999)
Gatačko polje, SE Herzegovina	947	1970s/80s (unknown date)	species present	Obratil (1999)
Japra posle Hašana, S Bosnia	263	31.7.1990	1 ind.	Karanović (1990)
Livanjsko polje, S Bosnia	702	1980s/90s	c.1000 calling ♂♂	Radović & Dumbović (2001)
Nević polje, Novi Travnik, C Bosnia	459	1.6.2000	7 calling ♂♂	N. Drocić in lit.
Gojevići - Fojnica, C Bosnia	618	May 2002	1 calling ♂ (first date)	Iviš D. (2008/09)
Bistrica polje, Žepče, C Bosnia	219	24.6.2002	1 calling ♂	N. Drocić in lit.
Ždralovac, Livanjsko polje, S Bosnia	700	5. - 7.7.2002	45 calling ♂♂ (early morning counts)	Schneider-Jacoby *et al.* (2006)
Gojevići - Fojnica, C Bosnia	613	11.5.2003	3 calling ♂♂	Iviš (2008/09)
Zenica, Raspotočju, C Bosnia	383	4.7.2003	2 calling ♂♂	N. Drocić in lit.
Bistrica polje, Žepče, C Bosnia	218	27.5.2004	3 calling ♂♂	N. Drocić in lit.
Sitnica, Ključ, C Bosnia	502	20.7.2004	1 calling ♂	S. Polak & P. Trontelj in lit.
Livanjsko polje, S Bosnia	702	1. - 3.6.2007	6 calling ♂♂ (daytime count)	Stumberger & Sackl (2008/09)
Livanjsko polje, S Bosnia	702	1. - 3.6.2007	314 calling ♂♂ (night count)	Stumberger *et al.* (2010)
Glamočko polje, S Bosnia	883	8.6.2007	3 calling ♂♂ (night count)	L. Božič & J. Smole in lit.
Šuičko polje, S Bosnia	914	9.6.2007	10 calling ♂♂ (night count)	L. Božič & J. Smole in lit.
Duvanjsko polje, S Bosnia	865	9.6.2007	31 calling ♂♂ (night count)	L. Božič & J. Smole in lit., Ozimec *et al.* (2013)
Livanjsko polje, S Bosnia	702	27. - 30.5.2009	23 calling ♂♂ (daytime count)	Stumberger & Sackl (2008/09)
Livanjsko polje, S Bosnia	702	27. - 30.5.2009	315 calling ♂♂ (night count)	Stumberger *et al.* (2010)
Haljinići, C Bosnia	490	11.5.2008	1 calling ♂ (first date)	Dervović (2008/09)
Haljinići, C Bosnia	507	2008 (breeding season)	max. 6 calling ♂♂	Dervović (2008/09)
Gojevići - Fojnica, C Bosnia	684	13.5.2008	1 calling ♂ (first date)	Iviš (2008/09)
Planina Vitreusa, Požetva, C Bosnia	1224	8.6.2008	2 calling ♂♂ (daytime)	I. Dervović unpubl. data
Gojevići - Fojnica, C Bosnia	618	13.5. - 14.7.2008	max. 5 calling ♂♂	Iviš (2008/09)
Gojevići - Fojnica, C Bosnia	775	21.8.2008	1 juv. (corpse)	Iviš (2008/09)
Močvara Bistrik - Haljinići, C Bosnia	519	2008 - 2012	2 - 5 breeding pairs	Kotrošan & Hatibović (2012)
Haljinići, C Bosnia	461	21.5.2009	1 calling ♂	D. Kotrošan unpubl. data
Seoca, C Bosnia	493	21.5.2009	5 calling ♂♂	D. Kotrošan unpubl. data
Uloško jezero, Ulog, Herzegovina	1081	26.5.2009	1 calling ♂	D. Kotrošan unpubl. data
Tjentište, SE Bosnia	575	28.5.2009	1 calling ♂	D. Kotrošan unpubl. data
Dabarsko polje, Herzegovina	476	19.7.2009	4 calling ♂♂ (20 - 21 h CET)	Schneider-Jacoby (2010)
Kraljeva Sutjeska, C Bosnia	478	7.6.2010	1 calling ♂	D. Kotrošan unpubl. data
Bištrani, C Bosnia	603	7.6.2010	2 calling ♂♂	D. Kotrošan unpubl. data
Gaja - Haljinići, C Bosnia	457	7.6.2010	8 calling ♂♂	D. Kotrošan unpubl. data
Bulčići - Visoko, C Bosnia	614	7.6.2010	1 calling ♂	D. Kotrošan unpubl. data
Seoca, C Bosnia	493	7.6.2010	1 calling ♂	D. Kotrošan unpubl. data
Bućovaća, Vukovsko polje, S Bosnia	1212	8.6.2010	25 calling ♂♂ (night count)	D. Kotrošan unpubl. data
Gojevići - Fojnica, C Bosnia	624	3.7.2010	3 calling ♂♂ (night count)	I. Dervović unpubl. data
Uloško jezero, Ulog, Herzegovina	1081	12.7.2010	1 calling ♂ (during day)	I. Dervović unpubl. data
Nević polje, Novi Travnik, C Bosnia	450	7.6.2011	1 calling ♂ (during day)	N. Drocić in lit.
Masna bara - Planina Zelengora, SE Bosnia	1468	23.6.2011	1 calling ♂ (during day)	I. Dervović unpubl. data
Carica - Visoko, C Bosnia	538	12.5.2011	1 calling ♂ (night count)	I. Dervović unpubl. data
Hifa, Tešanj; C Bosnia	187	23.5.2012	2 calling ♂♂ (daytime)	N. Drocić in lit.
Bogdase, Livanjsko polje, S Bosnia	707	23.5.2012	1 calling ♂ (during day)	S. Ernst in lit.
Golješnica - Žepče, C Bosnia	342	11.6.2012	4 calling ♂♂ (night count)	N. Drocić in lit.
Šemenovci, Kupreško polje, S Bosnia	1121	18.6.2012	1 ind.	Topić *et al.* (2011/12)
Vitez, Počulice, C Bosnia	520	27.6.2012	4 calling ♂♂ (night count)	N. Drocić in lit.
Hifa, Tešanj, C Bosnia	229	6.6.2013	1 calling ♂ (during day)	N. Drocić in lit.
Kraljeva Sutjeska - Haljinići, C Bosnia	459	15.6.2013	8 calling ♂♂ (night count)	I. Dervović unpubl. data
Lukovo brdo - Kakanj, C Bosnia	565	18.6.2013	1 calling ♂ (night count)	I. Dervović unpubl. data
Lužnica - Visoko, C Bosnia	530	18.6.2013	2 calling ♂♂ (night count)	I. Dervović unpubl. data
Vrela - Visoko, C Bosnia	516	19.6.2013	1 calling ♂ (during day)	I. Dervović unpubl. data
Nišićka visoravan, Ilijaš, C Bosnia	975	20.6.2013	3 calling ♂♂ (night count)	I. Dervović unpubl. data
Žepačko polje, Žepče, C Bosnia	225	26.6.2013	2 calling ♂♂	N. Drocić in lit.

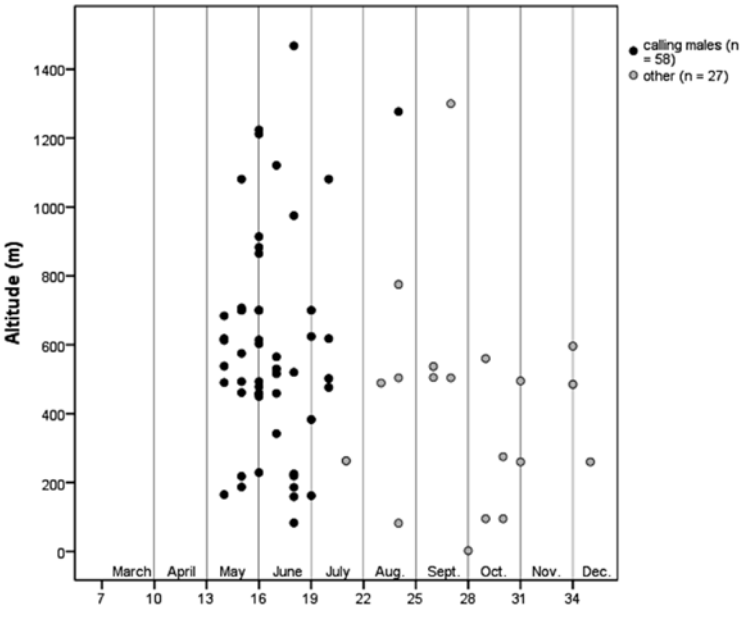

Fig. 1: Seasonal and altitudinal distribution of Corncrakes in Bosnia-Herzegovina according to collected specimens and occasional reports, 1847 – 2013.

During the period 1888 - 1911 most records (n = 23) date from autumn migration in September until mid-November, including three December records in 1890 and 1897, while all remaining observations until 2013 were conducted during the breeding season (n = 61). Although numerous winter records are known from western Europe in the 19th century when breeding populations were much larger (Glutz von Blotzheim *et al.* 1973, del Hoyo *et al.* 1996), the fact that O. Reiser observed no Corncrakes in Livanjsko polje, although he visited the area and other karst poljes several times in May and June during the 1890s and 1911, remains unexpected (Schneider-Jacoby *et al.* 2006). An explanation for the unbalanced distribution of his records between autumn migration and the breeding season may derive from extensive grazing pressures in the karst poljes during the Austro-Hungarian Monarchy which may have been reduced following to depopulation and economic recession in the wake of World War I (1914 – 1918).

Records from the 19th and 20th centuries and occasional observations since the last war in Bosnia (s. Fig. 1) cover altitudes between a few meters above sea-level, where two migrants were shot in Hutovo blato in October 1888 (Reiser 1939), up to Vitreusa Planina, Požetva in 1,224 m (2 males, June 2008) and 1,468 m a.s.l. on Zelengora Planina, Masna bara in south-eastern Bosnia (1 male, June 2011; both later observations by I. Dervović *unpubl. data*). Fig. 1 further indicates that in lower altitudes most males may arrive in (early) mid-May (first dates 11 and 12 May), while the uplands above 800 meters a.s.l. are colonized from late May and early June onwards (cf. Schäffer & Koffijberg 2004).

4.2 Distribution

Out of the 20 karst poljes which were visited in June 2012, 17 (85%) harboured Corncrakes. On the contrary, calling males were found in 28 (65%) of 43 karst poljes in 2013 (Fig. 2), including a number of smaller poljes. Overall, in both years Corncrakes were present in 29 (66%) of all karst poljes (n = 44). Only in two poljes, which were visited 2012 as well as 2013, i.e. Vukovsko polje and Hutovo blato, no Corncrakes were observed (Tab. 3). Vukovsko polje is a rather large polje, but with a comparatively small maximum flood surface (0.4 km^2) which was recently cultivated for silage and maize production, while Hutovo blato constitutes the only totally and permanently flooded karst polje in Bosnia-Herzegovina.

In accordance with occasional observations (s. 4.1 Historic records) singing males were found in all altitudes between 58 m in Rastoka i Ljubuško polje, Herzegovina, and 1,186 m a.s.l. in Kruško polje in western Bosnia. As shown in Fig. 3, along altitudes Corncrake numbers closely corresponded to total survey areas in different altitudinal belts. Hence, altitude had no effect neither on the number of calling males ($F_{10,34}$ = 0.62, P = 0.79) nor population density ($F_{10,34}$ = 0.94, P = 0.51). We further found no differences between the surface area of colonized and karst poljes without Corncrakes ($F_{1,42}$ = 1.56, P = 0.22); the area of the latter ranging from 1.4 – 408.0 km^2 (x = 44.4 km^2, sd = 80.2).

4.3 Population density

With total numbers of 413 and 644 males in 2012 and 2013, respectively, population numbers increased linearly to the survey area (≈ surface area) of individual poljes (r = 0.90, P < 0.001). Overall, breeding densities varied between 0.1 males/km^2 in Kupreško and Popovo polje, up to 6.1 males/km^2 in Lukavačko polje (Tab. 3), while the mean density of positive counts across individual karst poljes (n = 45) amounted to 1.0 male/km^2, sd = 1.1 (median = 0.5 males/km^2; Q_{25} - Q_{75}: 0.3 – 1.3 males/km^2).

For assessing the habitat quality of individual poljes we

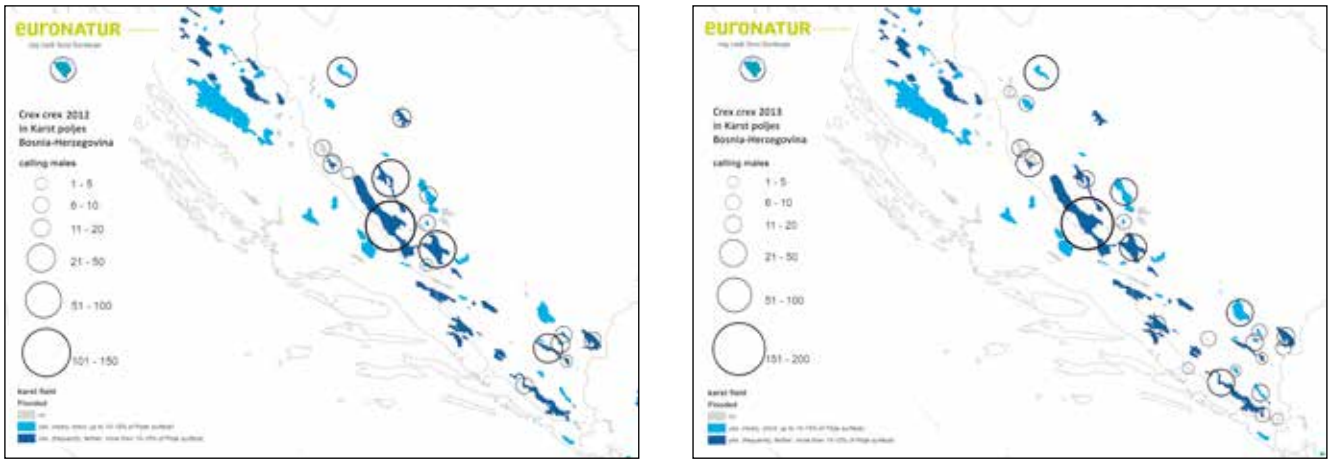

Fig. 2a-b: Distribution of Corncrake in the karst poljes of Bosnia-Herzegovina, 2012 and 2013.

calculated the relationship between survey (≈ surface) area and the population density of calling males (Fig. 4). In contrast to population numbers, breeding density declined with survey area (r = -0.28, P = 0.06). Due to deviation from the expected population density in Fig. 4, exceptionally high abundances of calling males were observed in Pašića (1.0 – 2.3 males), Lušci (1.8 - 2.4 males), Šuičko (3.3 males) and Lukavačko polje (4.5 – 6.1 males/km²).

4.4 Population density and flood type

For testing the effect of flood conditions on the presence and population numbers of Corncrakes we defined karst poljes with maximum flood surfaces (*fide* Schwarz 2013), which cover < 1% of the polje's respective total surface area, as dry poljes. According to this classification, 32 poljes were classified as temporarily flooded and 12 poljes as dry karst poljes (cf. Tab. 1 & 3).

Corncrakes were observed in 5 dry (42%) and 24 flooded poljes (75%). Population numbers fluctuated between 2 and 192 males (0.1 – 6.1 males/km², n = 40) in flooded and between 2 and 6 males (0.3 – 2.1 males/km², n = 5) in dry poljes (Fig. 5). As for survey (≈ surface) area, numbers of territorial males increased with flood area (r = 0.92, P < 0.001), while population densities were not linked to the

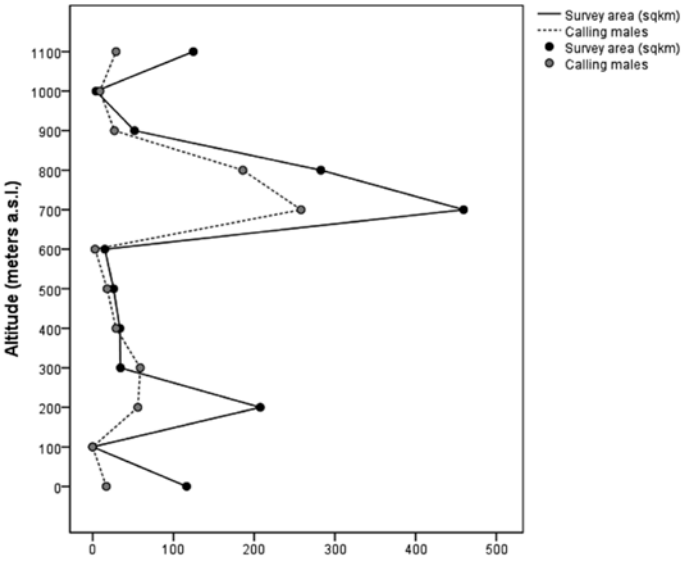

Fig. 3: Altitudinal distribution of calling males in the karst poljes of Bosnia-Herzegovina in relation to survey area in 2013 (43 counts)

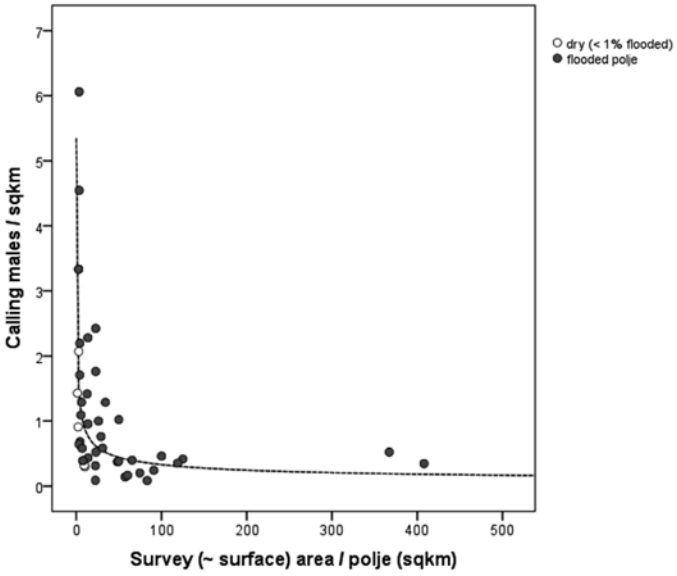

Fig. 4: Relationship between the survey (≈ surface) area in individual karst poljes and Corncrake breeding density, 2012 and 2013.

Tab. 3: Population numbers and breeding densities (calling males) of Corncrakes in karst poljes in Bosnia-Herzegovina, 2012 and 2013 (45 counts).

Karst polje	Flood type	Survey area (km²)		Number calling ♂♂		Calling ♂♂/km²	
		2012	2013	2012	2013	2012	2013
Kruško polje	dry		3.6		0		0
Vukovsko polje	flooded	28.1	28.1	0	0	0	0
Ravna Mliništa	flooded		4.4		3		0.7
Ravanjsko polje	dry		19.2		0		0
Kupreško polje	flooded	56.8	65.0	8	26	0.1	0.4
Borovo polje	dry		4.0		0		0
Slato polje	flooded	4.1	4.1	9	7	2.2	1.7
Vučipolje	dry		1.1		0		0
Gatačko polje	flooded	60.1	48.1	10	18	0.2	0.4
Šuičko polje	flooded	2.7	2.7	9	9	3.3	3.3
Roško polje	flooded	3.1		2		0.7	
Rakitno	flooded		14.1		0		0
Glamočko polje	flooded	49.9	49.9	51	19	1.0	0.4
Duvanjsko polje	flooded	125.0	100.0	52	46	0.4	0.5
Lukavačko polje	flooded	3.3	3.3	20	15	6.1	4.5
Konjsko polje	dry		1.4		2		1.4
Nevesinjsko polje	flooded		54.3		22		0.4
Cernica	flooded	5.5	5.5	0	6	0	1.1
Pašića polje	flooded	13.6	13.6	13	31	1.0	2.3
Marinkovci	dry		10.1		3		0.3
Grahovsko polje	flooded	13.8	23.0	6	12	0.4	0.5
Dugo polje	dry		2.5		0		0
Podrašničko polje	flooded	30.8	34.2	18	44	0.6	1.3
Livanjsko polje	flooded	408.0	367.2	141	192	0.4	0.5
Petrovačko polje	flooded	22.4	22.4	2	7	0.1	0.3
Medeno polje	dry		5.7		0		0
Bjelajsko polje	dry		9.4		3		0.3
Posušje	flooded		13.0		0		0
Ljubomir polje	flooded		12.7		18		1.4
Carevo polje	dry		0.3		0		0
Dabarsko polje	flooded	28.9	26.0	22	26	0.8	1.0
Fatničko polje	flooded	7.7	7.7	3	3	0.4	0.4
Ljubinjsko polje	flooded		6.9		4		0.6
Palanka (Lušci polje)	flooded	22.7	22.7	40	55	1.8	2.4
Kočerinsko polje	flooded		4.9		0		0
Mokro polje (Trebinje)	flooded		6.2		8		1.3
Mokro polje (Široki Brijeg)	flooded		2.8		0		0
Imotsko (Bekijsko) polje	flooded		43.7		0		0
Popovo polje	flooded	83.2	118.9	7	42	0.1	0.4
Mostarsko blato	flooded		33.1		0		0
Crničko polje	dry		2.9		6		2.1
Gradac	dry		2.2		2		0.9
Rastoka/Ljubuško polje	flooded		74.5		15		0.2
Hutovo blato	flooded		32.7		0		0
Total		**969.7**	**1308.1**	**413**	**644**	**0.4**	**0.5**

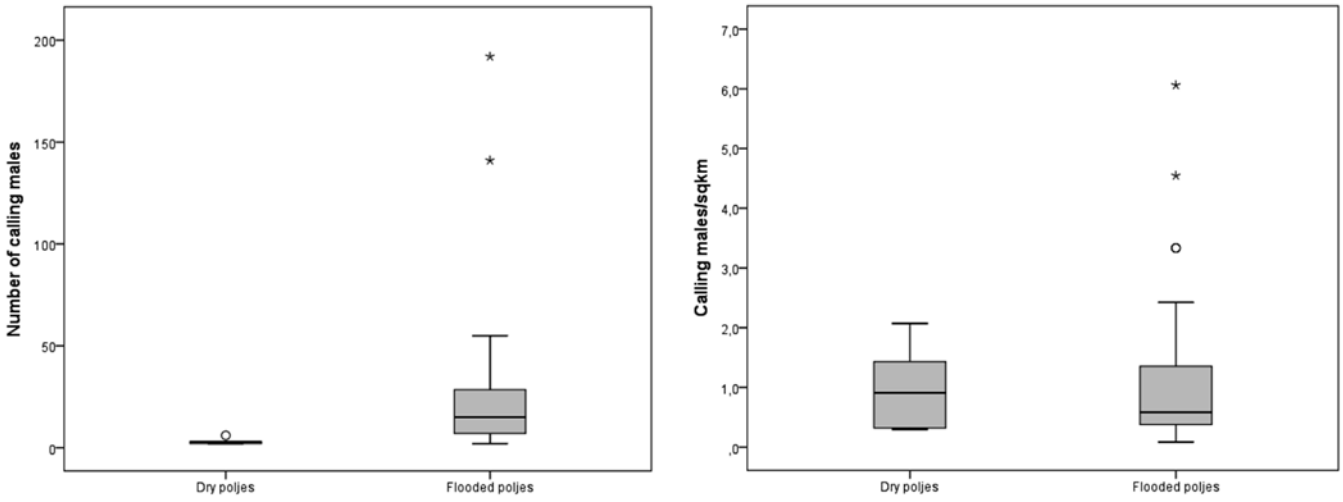

Fig. 5a-b: Population numbers and breeding density of Corncrakes in dry and periodically flooded karst poljes (s. 4.4) in Bosnia-Herzegovina, 2012 and 2013 (45 counts).

maximum flood surface of individual poljes (r = -0.23, P = 0.13, n = 45). Additionally, by applying Mann-Whitney-U statistics, in contrast to absolute numbers of calling males (Z = 3.04, P = 0.02), no statistically significant differences between population densities in dry and flooded karst poljes (Z = 0.04, P = 0.97) were found (Fig. 5).

4.5 Annual population numbers

Total population numbers in 2012 and 2013 and the comparison of counts for individual poljes which were visited in both study years (n = 18), indicate larger numbers of calling males in 2013. From 2012 to 2013 the population declined by 32 males in Glamočko polje, while in Livanjsko polje a considerable increase of 51 males was documented (cf. Tab. 3). Overall, the average population number in individual poljes was 9.7 males (sd = 19.2) higher in 2013. In contrast, respective numbers of calling males in karst poljes (total area 268.3 km^2) which were investigated in both years in early or in late June, show opposite trends (Tab. 3). By comparing the population numbers of poljes which were visited during the same season in 2012 and 2013, in half of the poljes fewer males were noted, while in only one polje numbers were considerably higher in 2013 (x = -1.9 males, sd = 15.8, n = 8). In addition, annual means of calling males/km^2 (1.1 males/km^2, sd = 1.5, n = 17 vs. 1.1 males/km^2, sd = 1.0, n = 28) as well as overall population density (0.4 vs. 0.5 males/km^2) did not differ significantly between 2012 and 2013. Thus, the higher number of territorial males in many poljes in 2013 may be a result of differing seasons of the survey in 2012 and 2013.

4.6 Calling groups

During the present study the highest concentration of 192 males was registered in the Ždralovac area in Livanjsko polje in late June 2013, where territorial birds moulded into a 200 – 1,400 m wide continuous carpet of singing males along the lower flood surface of the polje comparable to counts in 2007 and 2009 (Stumberger *et al.* 2010). Aside from the outlier in the northern parts of Livanjsko polje, calling groups consisted of 2 - 46 males (n = 36). The median size of calling groups amounted to 7.0 males (Q_{25} - Q_{75}: 4.0 – 18.8 males) of which more then 60% included ≥ 7 birds and 25% encompassed ≥ 19 males. Compared to occasional counts, calling groups are smaller in mountain regions outside karst poljes (cf. night-time counts in Tab. 2).

5. Discussion

5.1 Distribution and habitat conditions

National counts since 1992 and 1993 showed that 60% - 80% of the Corncrake population in Slovenia (300 – 700 calling males) are concentrated in the country's Dinaric region which encompasses the northern foothills of the Dinarides (Trontelj 1997, 2001, Božič 2005, DOPPS 2009,

2010). More than half of the Slovenian population was found in karst poljes. Similarly, Peštersko and Sjeničko polje, situated in the karst areas of south-western Serbia, harbour comparatively large numbers of calling males, currently estimated at 40 – 60 males (Puzović *et al.* 2009, Sekulić 2011). In nearby Koštan polje the species may inhabit similar grassland habitats. In addition, Dumbović Mazal & Tutiš (2013) recently reported 290 – 500 territorial males for the Lika karst poljes in Croatia. In the same way, the present study in Bosnia-Herzegovina confirmed the significance of karst poljes for Corncrakes (cf. Schneider-Jacoby 1991, Trontelj 1997).

In Bosnia-Herzegovina, like in other countries in the Dinaric Karst, the species was further found in different mountain and subalpine grassland habitats outside karst poljes during the breeding season (s. 4.1 Historic records, Tab. 2). However, regarding the small numbers (maximum of 8 singing males near Haljinići, 510 m a.s.l., in June 2010 and 2013) and the scarcity of records, Corncrakes distribution is apparently more scattered in the mostly dry and rocky grasslands in the uplands of the Dinaric Karst, where rain and snowmelt rapidly enter the limestone bedrock (Bonacci 1987). Additionally, the species was not found on the south-eastern slopes of the 1,757 m high Velebit Massif in Dalmatia during extensive breeding bird surveys from 1992 until 2009 conducted in Croatia's 95 km^2 large Paklenica National Park (Lukač 2011). According to current knowledge, the distribution of obviously small and geographically isolated populations in the foothills and higher mountains of the Western Balkans is restricted to the inundation zones of periodically flooded lakes, like Pošćensko Lake (1003 m) in Montenegro (M. Jovićević *pers. comm.)* and infrequently mown (or abandoned) grasslands above waterlogged deposits, like the slopes of Mt. Snežnik located between 500 – 1,000 m a.s.l. in Slovenia (S. Polak *pers. comm.*) and the Prokletije Mountains in Kosovo and Montenegro (Puzović *et al.* 2003, M. Jovićević *pers. comm.*).

In comparison to dry (fossil) poljes and poljes with proportionally small flood surfaces, the karst poljes with large-scale periodical flooding harboured 97% - 99% of the overall Corncrake population (Tab. 3). Although numbers of territorial males increased with the maximum flood surface of the poljes, we found no differences between population densities in dry and periodically flooded karst poljes. While population numbers may fluctuate heavily between as well as within seasons (s. 4.5 Annual population numbers), even fossil karst poljes without surface water sources, like Gradac, Konjsko and Crniško polje, can harbour viable Corncrake numbers. According to highly differentiated flood water-levels, flooding season, flood duration and vegetation type, the maximum flood surfaces per se (estimated by Schwarz 2013) are inadequate for predicting Corncrake numbers for individual karst poljes.

While growth height, vegetation density and mowing dates in karst poljes fluctuate according to flood conditions (Bonacci 1987), Corncrakes prefer at least 20 – 30 cm tall vegetation and depend on late mowing dates of grassland habitats managed by farmers. Many authors further addressed the positive correlation between soil moisture (flood duration) and the appearance and population numbers of Corncrakes (e.g., Glutz von Blotzheim *et al.* 1973, Schäffer 1999, Schäffer & Koffijberg 2004). In 2012 and 2013 Šuičko, Glamočko, Lukavačko, Dabarsko and Crničko polje harboured exceptionally high numbers of calling males which significantly exceeded breeding densities predicted by survey area (cf. Fig. 4). According to current habitat surveys in a number of karst poljes conducted by Bronner (2014), poljes harbouring large numbers of Corncrakes are characterized by extensive stands of wet Dechampsion and Molinion meadows, gradients between wet and dry grasslands, and small-scale mosaics of meadows, arable fields and pastures. In contrast, grassland habitats of poljes with comparably low numbers of calling males, like Gatačko, Nevesinjsko, Fatničko and Popovo polje, are heavily impacted by grazing, drainage and large-scale agriculture (Bronner 2014).

In comparison to dry (fossil) poljes and poljes with proportionally small flood surfaces, the karst poljes with large-scale periodical flooding harboured 97% - 99% of the overall Corncrake population.

5.2 Population numbers and threats

Although almost all periodically flooded poljes were visited for the present study, overall population numbers for the karst poljes of Bosnia-Herzegovina remain preliminary. Besides seasonal movements between poljes following to flood conditions and phenology of vegetation types (c.f. Schäffer & Koffijberg 2004), concentrations of calling males in some former war-zones are extremely difficult to count. The latter particularly concerns the Ždralovac area in the upper parts of Livanjsko polje, where night-time singing places are concentrated in a continuous, up to 1,400 m wide carpet parallel to the only safe access road (cf. Stumberger *et al.* 2010).

With the exception of only 3.3 km² large Lukavačko polje which harboured exceptionally high breeding numbers (4.5 – 6.1 males/km²), breeding densities throughout the karst poljes of Bosnia-Herzegovina fit well into the range of 0.1 – 3.5 calling males/km², which were found in randomly selected sample plots in Latvia (Keišs 1997) and Estonia (Elts 1997). However, by adding up minimum and maximum numbers for individual poljes, total population numbers in 2012 and 2013 amounted to 460 – 690 males. According to the close relationship between surface area and Corncrake numbers, those poljes not included in the present study may harbour another 20 – 30 males. Taking into account some occasional counts in Duvanjsko, Šuičko and Dabarsko polje, between 2007 and 2010, the total population in the karst poljes of Bosnia-Herzegovina is roughly estimated at 480 – 790 calling males.

According to present data, the Corncrake population in Bosnia-Herzegovina may exceed current estimates of 500 – 800 territorial males (Kotrošan *et al.* 2012). However, in the Ždralovac area in Livanjsko polje Corncrake numbers declined by 40% - 55% since 2007. During current counts no Corncrakes were found in Vukovsko polje, although in early June 2010 at least 25 calling males were present in the area. In both cases – just like in Mostarsko blato by artificial flooding - formerly extensive wetland habitats and traditionally used grasslands were recently replaced by arable fields for maize cultivation and silage. Besides cultivation and intensification of farmland management, the planned construction of hydropower plants in Glamočko, Duvanjsko and Livanjsko polje in the drainage area of the upper Cetina River will affect 13% - 27% of the overall Corncrake population in Bosnia-Herzegovina's karst poljes. At the same time the realization of the "Upper Horizons" project, for which a cascade of 7 hydropower plants is projected, will impact the hydrological regimes of wetland and grassland habitats in at least 10 karst poljes in the Neretva River basin - including Nevesinjsko, Lukavačko and Dabarsko polje - which together harboured 61 and 129 calling males, i.e. 15% - 20% of the total population, in 2012 and 2013. Hence, the cumulative impacts of hydropower development in the upper Cetina and Neretva River basins will affect 28% - 47% of the total Corncrake population. Additionally, in the near future adequate breeding habitats in former war-zones which currently harbour substantial numbers of territorial males will be lost as a result of natural succession.

Although night-time counts remain too occasional for calculating reliable population trends, the Corncrake population in the karst poljes of Bosnia-Herzegovina exceeds population numbers in many Western European countries. With regard to current threats, the population needs to be intensely monitored. While future counts may be restricted to poljes inhabited by substantial numbers of ≥ 25 males (s. Tab. 3), we recommend meeting international standards for Corncrake monitoring (cf. Schäffer 1994, Gilbert *et al.* 1998). Tyler & Green (1996) and other studies have shown that the singing activity of males changes according to status of pair-bond during season. According to recoveries of ringed birds, Corncrakes may further move widely between poljes and potential breeding habitats outside karst poljes and the Dinaric region (Schäffer 1999, Schäffer & Koffijberg 2004). Therefore, it will be essential for future investigations to count poljes - as far as possible – simultaneously and to establish two consecutive counts for individual karst poljes in late May/early June and in late June/early July, respectively.

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