

Where can flood refugees go? Re-distribution of Corncrakes (*Crex crex*) due to floods and its consequences on grassland conservation in north-eastern Hungary

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Summary The Corncrake is a threatened umbrella species for wet meadows, which mostly depends on managed grasslands. Therefore, effective conservation requires bird-friendly land management schemes and subsidies. Although the most important populations in Hungary usually breed in protected areas, some of these are regularly flooded, which forces Corncrakes to find breeding sites elsewhere. Such movements from protected/subsidised areas to suboptimal sites have risks for Corncrake populations and their conservation. Here, we describe a large-scale dynamic system of interlinked populations based on data from 4194 Corncrake territories found at four different sites (Aggtelek, Bodrogszug, Szatmár-Bereg and Zemplén regions) across eight years between 1997 and 2006 in NE Hungary (c. 1500 km²). The results showed that the total population fluctuated between 407 and 631 pairs and that the populations were more-or-less stable in the first four years (1997–2000). However, extended floods caused the disappearance of the species from the Bodrogszug region in 2005–2006, while in the other sites, the number of territories increased five-fold (Zemplén), three-fold (Aggtelek) and two-fold (Szatmár-Bereg). The correlation between the number of territories and maximum water level of river Tisza in April–May was negative in the Bodrogszug site and positive in the three other sites, indicating that interlinkages of the populations were associated with water levels. Our data thus support the hypothesis that many of the birds driven out by inundation of floodplain meadows moved to other sites in NE Hungary in flood years. These results suggest that even large, centrally located populations of Corncrake can be greatly exposed to risks of flooding and that it is highly important to maintain suitable alternative breeding sites for the species. The High Natural Value Areas programme may allow administrative and funding support to provide or extend protection and/or subsidies to maintain this large-scale dynamic system. To this end, the area managed in bird-friendly ways and subsidised under agri-environmental schemes was extended by 35,000 hectares in NE Hungary in 2009.

Keywords: Corncrake, High Nature Value Areas, grassland protection, agri-environment schemes, landscape scale

Összefoglalás A haris a nedves gyepek kitüntetett ernyőfaja. A faj napjainkban leginkább mezőgazdasági hasznosítású gyepterületekhez kötődik, ezért hatékony védelme madárbarát gazdálkodási gyakorlatot és agrár-támogatásokat igényel. Habár a legjelentősebb hazai állományok védett területeken költenek, ezen területeket rendszeresen érik áradások, melyek más költőhelyek keresésére kényszeríthetik a harisokat. A védett/támogatott területekről szuboptimális költőhelyekre történő mozgások kockázatosak lehetnek a haris-állományokra, és kihívást jelentenek a védelem számára. Dolgozatunkban négy állomány nagy térbeli léptékű, dinamikus kapcsoltságú rendszerét ismertetjük négy északkelet-magyarországi helyszínen (Aggtelek, Bodrogszug, Szatmár-Bereg, Zemplén) nyolc éven át (1997–2006) gyűjtött 4194 haris-territórium adata alapján. Az összesített állomány 407 és 631 pár között változott, és az első négy vizsgálati évben (1997–2000) viszonylag stabil volt az egyes helyszíneken. A második négyéves periódus végére (2005–2006) azonban a bodrogszugi állomány szinte eltűnt a hosszú árvizek hatására,

míg a többi helyszínen a territóriumok száma megduplázódott (Szatmár-Bereg), illetve a háromszorosára (Aggtelek) vagy ötszörösére nőtt (Zemplén). A territóriumok száma és a Tisza április-májusi maximum vízállása közötti korreláció negatív volt a Bodrogzug esetén, és pozitív a többi helyszín esetén, mely arra utal, hogy az állományok közötti kapcsolatok összefüggésben voltak a vízállással. Adataink ezért alátámasztják azt az elképzelést, miszerint a nyílt ártéri rétek elárasztása révén költőhelyükről elüldözött madarak más északkelet-magyarországi helyszínekre kényszerülnek az árvízes években. Ezek az eredmények azt mutatják, hogy még nagy, középponti helyzetben levő haris-állományok (pl. Bodrogzug) számára is kockázatokat jelenthet az árvíz, és ezért megfelelő alternatív költőhelyeket kell fenntartani a fajnak. A Magas Természeti Értékű Területek program adminisztratív és anyagi segítséget nyújthat a védelem és a támogatások biztosítására és kiterjesztésére e nagy térbeli léptéken működő dinamikus rendszer fenntartása érdekében. E célból történt meg a madárbarát művelési gyakorlat és az agrár-környezetvédelmi támogatási rendszerek áttervezése és bővítése újabb, összesen 35 000 hektár területre Északkelet-Magyarországon 2009-ben.

Kulcsszavak: haris, Magas Természeti Értékű Területek, füves élőhelyek védelme, agrár-környezetgazdálkodási rendszer, tájlépték

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Introduction

Grasslands cover approximately 40% of the terrestrial area of the world, and about 20% of Europe (Suttie *et al.* 2005). Grasslands are important habitats for wildlife, but at the same time, they are also significant for agricultural production (Hopkins & Holz 2006). The area of grasslands in Europe has decreased during the past decades, whereas the management of the remaining areas has intensified (European Environment Agency 2007, Pe'er *et al.* 2014). The decline in biodiversity in grasslands due to agricultural intensification is well-known all over Europe (Chamberlain *et al.* 2000, Donald *et al.* 2001, Benton *et al.* 2002, Donald *et al.* 2006, Henle *et al.* 2008, Kleijn *et al.* 2009, Pe'er *et al.* 2014).

The Corncrake is known to depend on managed grasslands (Green *et al.* 1997, Schäffer & Koffijberg 2004), but the increased intensity of grassland management has a negative impact on this species (Green & Rayment 1996, Berg & Gustavson 2007). Consequently, the population size of this formerly abundant bird has decreased in major parts of its Eurasian breeding range (Green *et al.* 1997, Keiřs 2005, Keiřs *et al.* 2007). The northern and western European populations in particular are scattered and are now endangered (Green 1995, Crockford *et al.* 1996, Schäffer & Koffijberg 2004). In contrast, populations in Central and Eastern Europe (CEE) were reported to increase (Koffijberg *et al.* 2016), which may be related to the disappearance of the collective farming systems and general temporary extensification of agriculture due to the collapse of the socialist economy (e.g. Elts 1997, Keiřs 1997, Schäffer & Green 2001, Keiřs 2005, Koffijberg & Schäffer, 2006, Koffijberg *et al.* 2016). In addition, comprehensive conservation schemes have been established in several

countries (Stowe & Green 1997, O'Brien *et al.* 2006, Schoppers & Koffijberg 2006, Beaumont & England 2016). Otherwise, abandonment of management of grasslands, which has been occurring in many CEE areas, enhances vegetation succession and eventually drives out Corncrakes as the vegetation becomes too dense (Schäffer & Koffijberg 2004, Koffijberg *et al.* 2016).

Today, agricultural subsidies increasingly result in the expansion of arable lands and in a simultaneous reduction and even more intensive use of grasslands, especially in the new CEE member states of the EU (e.g. Pe'er *et al.* 2014), which is unfavourable for Corncrakes (Keiřs 2005, Koffijberg & Schäffer 2006, Biró *et al.* 2013). However, there are different kinds of subsidies within agri-environment measures, and some, such as the High Nature Value Area programmes, were introduced to maintain Corncrake-friendly management regimes in grasslands (European Commission 2005, Sztahura & Rezneki 2015). However, finding measures that are both beneficial for the Corncrake and other grassland birds and profitable to farmers in agricultural areas is complicated and difficult (Kleijn *et al.* 2004, Berg & Gustavson 2007, Beaumont & England 2016). The administrative systems of subsidies are rigid and limited to defined areas and periods, however, the habitat use of Corncrakes is not. The long-distance movements of Corncrakes within a breeding season have been known for a long time (Bürger *et al.* 1998, Koffijberg & van Dijk 2001, Schäffer & Koffijberg 2004, Koffijberg *et al.* 2016), and this knowledge can be used for the designation of subsidised areas. These movements can also be triggered by floods, which have particular importance in the Carpathian Basin. If Corncrakes move from protected and/or subsidised areas threatened by floods to unfavourable breeding sites, such movements will have an important implication for Corncrake conservation. The Corncrake is an umbrella species as its protection covers other species of wet meadows (e.g. Wettstein & Szép 2003, Boldogh *et al.* 2016). In Hungary, three agri-environmental packages have measures that are relevant to Corncrakes within the Rural Development Programme (2015–2020) (Boldogh *et al.* 2016). These include the “bird-friendly mowing”, the “delayed mowing” and the “keeping unmown area” measures, which can be beneficial to the Corncrake, and obviously for other protected species (Green *et al.* 1997, Stowe & Green 1997, Beaumont & England 2016).

The main aims of this study were to (i) identify interlinkages among major Corncrake breeding sites in north-east Hungary, (ii) improve our interpretation of monitoring data on a national and regional scale, and (iii) to draw attention to the vulnerability of the most important breeding sites of Corncrakes in Hungary. Our general aim was to provide input for nature conservation authorities for the adequate designation of High Nature Value Grassland Areas and other protected sites.

Material and Methods

We surveyed populations of Corncrakes between 1997–2000 and 2003–2006 at four sites in NE Hungary (total 1475.3 km²) (*Figure 1*), following international guidelines and methods (Sheppard & Green 1994, Schäffer & Mammen 2003). Previous results suggested that

the most important breeding sites of the species were in this part of the country (Szép 1991, Boldogh 1999, Boldogh & Szentgyörgyi 2003).

Censuses of singing Corncrakes in the potential breeding habitats were conducted at night (23:00–03:30) throughout the breeding season (15 May–30 June). Data from surveys conducted before 15th May were excluded from the analyses to avoid overlap with the migration of birds. Most of the surveys were completed by mid-June, thus, the subsequent increase in the number of displaced males did not influence our results. We aimed to survey all suitable breeding sites regardless of their management regime or protection status and strived for similar sampling effort in all sites and years. In a single survey, c. 70–80% of the singing males can be recorded, hence 2–3 visits per site are recommended (Schäffer & Mammen 2003). Accordingly, we surveyed 75% of the study area at least twice and 15% of the area at least three (or more, up to six) times. Generally, at least five days passed between subsequent surveys. If a singing male was found less than 200 m apart at the same site during a subsequent survey, it was treated as the same individual. We inferred one territory when the same individual was heard at the same site subsequently on at least two (but often more, up to six) survey occasions. The location of calling males was determined by GPS or recorded on 1:25 000 and 1:10 000 topographic maps. [Figure 1]

The first site, the Aggtelek National Park and its surroundings (Aggtelek NP in *Figure 1*), is 1160 km². Dominant natural and semi natural habitats in the area are deciduous forests (e.g. *Quercetum petraeae-cerris*, *Quercus petraeae-Carpinetum*) and different grasslands (55% and 13%, respectively). Arable lands cover 30%. The most important breeding habitats are wet meadows (e.g. *Caricetum acutiformis-ripariae*, *Cirsio cani-Festucetum*

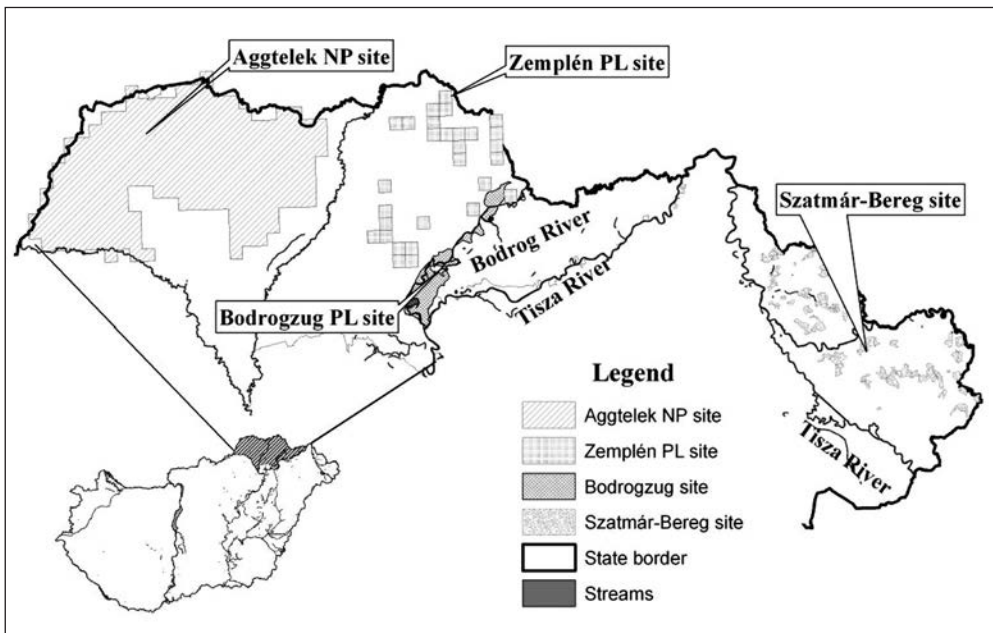


Figure 1. The distribution of the study sites in NE Hungary
1. ábra A vizsgálati helyszínek Északkelet-Magyarországon

pratensis) and abandoned pastures (Boldogh & Szentgyörgyi 2003) in the small river valleys (e.g. Szuha, Bódva valley). Most meadows are abandoned and overgrown with high vegetation, and less than 20% of the grasslands are managed. Flooding of the breeding habitats is infrequent and is restricted to small areas (Marosi & Somogyi 1990). Parts of the site are protected as Aggtelek NP (200 km²) (Homepage of the Hungarian State Nature Conservancy 2016).

The second site covers 125 km² in the Zemplén Mountains (Zemplén PL in *Figure 1*) and involves wet meadows mainly along small streams (e.g. Bózsva, Bényei). A large portion of the site is covered by wet meadows (e.g. *Agrostio-Deschampsietum caespitosae*, *Angelico-Cirsietum olerace*) and arable lands (60% and 15%, respectively). The majority of the meadows are unmanaged (not grazed or mowed). Floods are very rare here. Parts of the site are included in the Zemplén Landscape Protection Area (Homepage of the Hungarian State Nature Conservancy 2016).

The third site, the Bodrogzug and Bodrogmente, consists of 90.5 km² in the flood-plain of rivers Bodrog and Tisza (Bodrogzug PL in *Figure 1*). Riparian meadows (e.g. *Alopecuretum pratensis*, *Agrostetum albae*) and marshes are the dominant habitat types (70% and 15%, respectively). The intensity of management is moderate as less than 30% of the grasslands are managed, mainly used for mowing and grazing (80% and 20%, respectively). The threat of flooding is high (Marosi & Somogyi 1990). In years with high water level, 20–100% of the site is flooded mainly from April to June. This site is of great conservation interest because of breeding and migrating birds, therefore, it is protected and included in the Ramsar Convention of Wetlands (Tardy 2007) (Homepage of the Hungarian State Nature Conservancy 2016).

The fourth site, the Szatmár-Bereg lowland, is in the easternmost part of Hungary between rivers Tisza and Szamos, and consists of 99.8 km² (Szatmár-Bereg in *Figure 1*). Different grasslands (e.g. *Agrostetum albae*, *Alopecuri-Festucetum pseudovinae*) cover the whole territory (Wettstein *et al.* 2001, Wettstein & Szép 2003). Many are abandoned due to the decreasing number of livestock. A considerable part of the site is a floodplain of river Tisza and its tributaries. Parts of the site are protected as the Szatmár-Bereg Landscape Protection Area (Homepage of the Hungarian State Nature Conservancy 2016).

We studied the observed fluctuations of Corncrake populations at the four sites between 1997 and 2006, with the exception of 2001 and 2002, when surveys were not carried out at the Zemplén PL and Bodrogzug PL. We analysed the changes in the number of territories at the four sites in eight years and as a function of water level, using generalised least squares regression (function 'gls' in R package 'nlme'). This allows the specification of an autocorrelation structure, which, in our case, involved temporal (between-year) autocorrelation in the number of territories within sites (grouping factor). We characterised water levels by the maximum water level reading of river Tisza, measured at the checkpoint of Tokaj, during the settlement and breeding period of Corncrakes (April-May). We used the ArcMap 9.2 GIS software for determining the High Nature Value Programme status of the breeding sites and visualizing the results of the evaluation. All statistical analyses were performed in the R statistical environment (version 3.2.2, R Core Team 2015).

Results

In total, 4194 (100%) territories with singing Corncrakes were recorded at the study sites during 8 years. One thousand two hundred and fifty-seven (30%) Corncrake territories were at the Aggtelek NP site, 777 (18.5%) at the Zemplén PL site, 1281 (30.5%) at Bodrozug PL site and 879 (21%) in the Szatmár-Bereg site (*Table 1*). The total number of territories on the four sites fluctuated between 407 and 631 territories between 1997 and 2000, and between 427 and 580 territories between 2003 and 2006 (*Table 1*), and did not differ between the two time periods (mean±S.D., period 1: 544.5±96.35, period 2: 504.0±68.86; $t_6=0.684$, $p=0.520$). [*Table 1*]

The number of territories was relatively stable between 1997 and 2000 in the Bodrozug, Szatmár-Bereg and Zemplén sites and decreased in the Aggtelek site (*Figure 2*). In contrast with the last four years (2003–2006), Corncrakes have almost completely disappeared from the Bodrozug site, while the number of territories increased five-fold in the Zemplén PL site, three-fold in Aggtelek NP, and two-fold in the Szatmár-Bereg site (*Figure 2*). The generalised least squares regression showed a significant interaction between site and maximum water level of river Tisza in April–May ($F_{3,24}=4.846$, $p=0.009$), indicating that the correlation between Tisza water level and number of territories differed among the sites. This was because the correlation was negative for the Bodrozug site and generally positive for the three other sites (*Figure 3*). [*Figs. 2 and 3*]

The number of territories in the Bodrozug PL site strongly depended on maximum water level of river Tisza in April–May. If the water level of river Tisza at Tokaj exceeds 550 mm (c. 95 m above sea level), more than 80% of the Bodrozug area is inundated, whereas the entire Bodrozug area is inundated if water level on river Tisza exceeds 600 mm (*Figure 4*) (Vass 2014, Szabó *et al.* 2016). In flood years, the water levels were much higher than these values. For example, the maximum water level at Tokaj was 847 cm in 2001. When

Year	Aggtelek NP	Bodrozug PL	Szatmár-Bereg	Zemplén PL
1997	134	232	125	88
1998	216	238	96	81
1999	143	215	133	70
2000	47	199	81	80
2003	84	228	78	37
2004	140	158	70	101
2005	233	10	162	135
2006	260	1	134	185

Table 1. The number of territories estimated based on the presence of singing Corncrakes in the four study sites in NE Hungary in 1997–2006 (surveys were incomplete in 2001 and 2002). For details of different sites, please see *Materials and methods*

1. táblázat A haris territóriumok száma a harsogó hímek száma alapján az egyes mintaterületeken Északkelet-Magyarországon 1997–2006 között (2001-ben és 2002-ben a felmérések nem minden mintaterületen történtek meg). Az egyes területek leírása az *Anyag és módszerek* részben szerepel

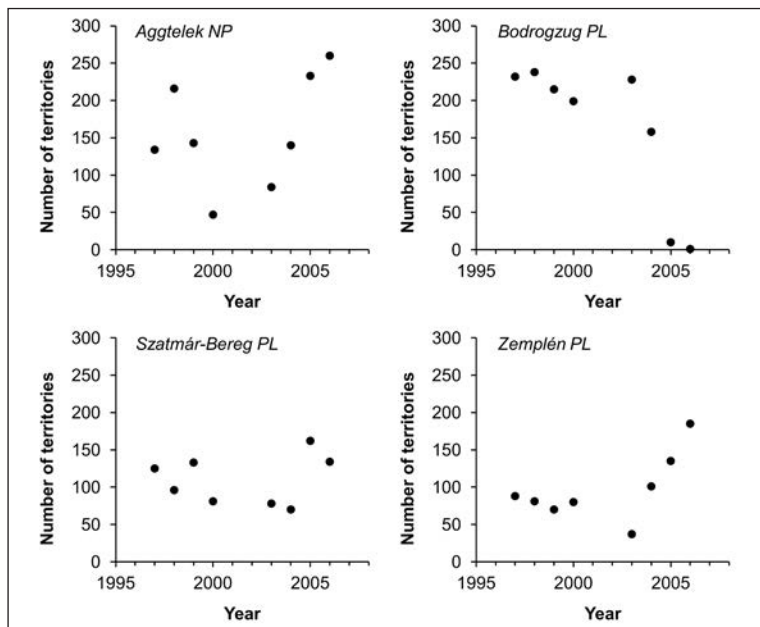


Figure 2. Number of Corncrake territories at the four study sites in the eight study years
2. ábra A haris-territóriumok száma a négy vizsgálati területen a nyolc felmért évben

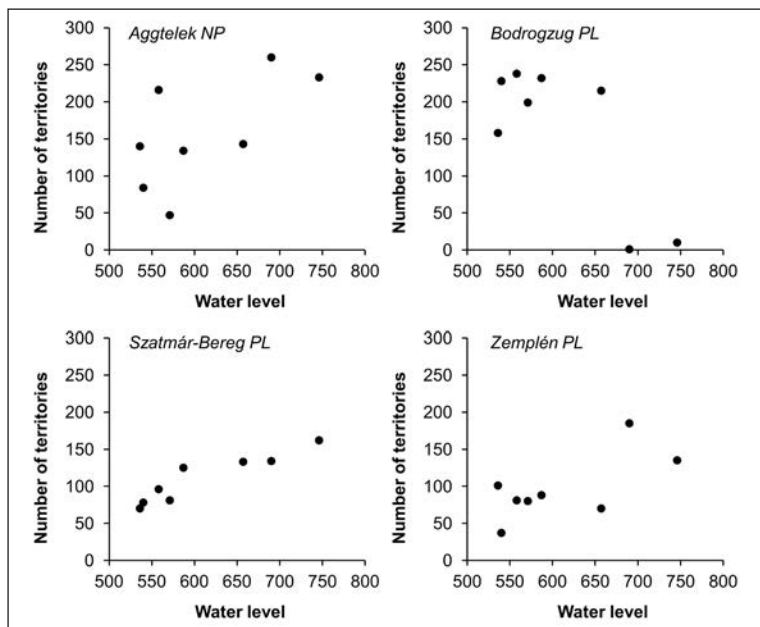


Figure 3. Number of Corncrake territories as a function of maximum water level of river Tisza at Tokaj in April-May (in cm) of each year

3. ábra A haris-territóriumok száma a Tokajnál április-májusban mért maximális vízállás (cm) függvényében

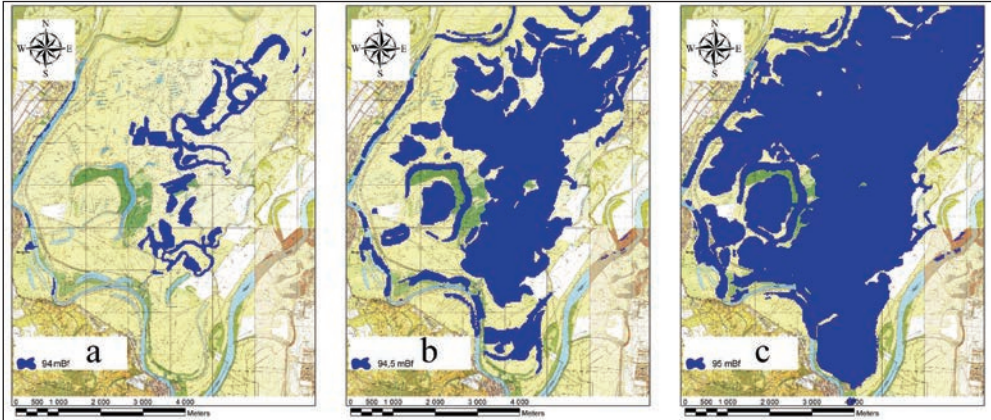


Figure 4. Area (in blue) inundated in the Bodrogzug PL site when the water level of river Tisza at Tokaj is at 94.0 m (a), 94.5 m (b) and 95 m (c) above sea level. Source (a-c): G. Molnár after the ÉKÖVIZIG (Miskolc) database

3. ábra. A Tisza által elöntött terület (kékkel) a Bodrogzugi TK területén, amikor a Tisza vízszintje eléri a 94 m-es (a), a 94.5 m-es (b) és a 95 m-es (c) tengerszint feletti szintet. Forrás (a-c): Molnár G. az ÉKÖVIZIG (Miskolc) adatai alapján

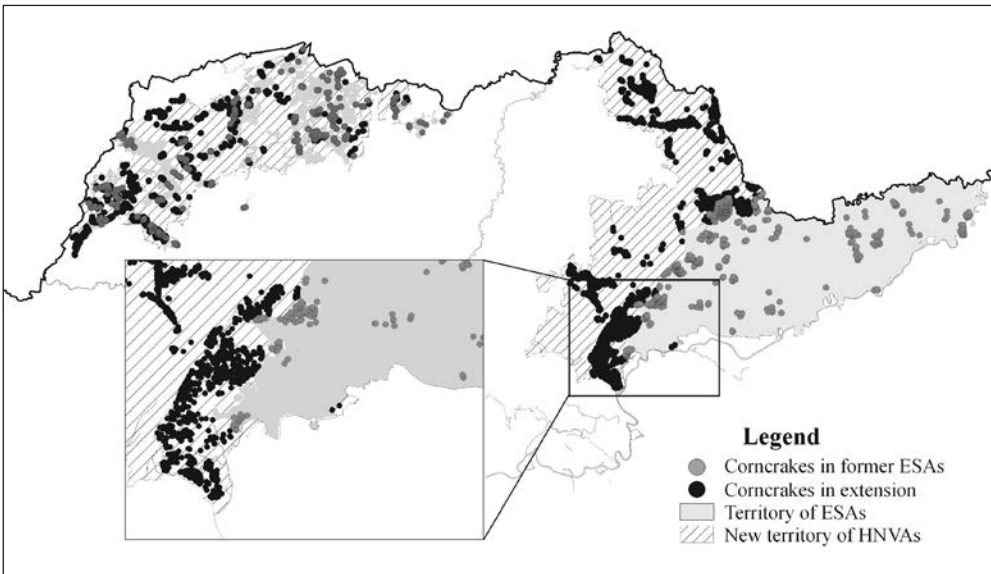


Figure 5. Distribution of Corncrake territories based on singing males observed during 1997–2006 in the previously designated subsidised territories (ESAs) and the enlargement of areas included under the High Nature Value Areas programme with consideration to the large-scale redistribution patterns of Corncrakes in NE Hungary

4. ábra A haris-territóriumok eloszlása az éneklő hímek alapján 1997 és 2006 között a korábbi agrártámogatási rendszer (ESA) területén, és a támogatási rendszerbe a Magas Természeti Érzékenységu Területek programon át újonnan, a haris újraelosztási mintázatának figyelembevételével bevont területeken Északkelet-Magyarországon

the maximum April-May water level was above 660 m in 2005 and 2006, Corncrakes almost disappeared from the site (*Figure 2*). In addition, in 2006, a long and intense flood in April (maximum level: 892 cm) was followed by a “green” flood in late May and early June. These years also showed large increases of the nesting population in the Aggtelek, Szatmár-Bereg and Zemplén sites, and the increase was greatest at the Zemplén site (*Figure 2*), which is closest to the Bodrogzug site (*Figure 1*). [Fig. 4]

Finally, none of the most abundant breeding sites was covered by any agri-environment subsidy schemes (e.g. ESA) until 2009 (*Figure 5*). However, the extension of HNVA's efficiently covered Corncrake breeding sites at three of the sites studied (*Figure 5*).

Discussion

The studied areas in NE Hungary hold the most important local Corncrake populations in the country (Boldogh *et al.* 2009, 2016), which are also remarkable even in an international context (Koffijberg *et al.* 2016). The sizes of the local populations fluctuate considerably, which was also reported for other populations of the breeding range (e.g. Keišs 2003, Sukhanova & Mischenko 2003, Schäffer & Koffijberg 2004, Schoppers & Koffijberg 2006, Koffijberg *et al.* 2016). However, our study is the first to report both concerted changes (period between 1997–2000) and negative correlations (period between 2003–2006) in the sizes of the local populations. In time period 2, population declines in the Bodrogzug PL site were in concert with population increases in the other local populations. Our results suggest that the different inter-population relationships between time period 1 (when only small floods occurred) and time period 2 (when extended floods occurred) may be explained by the flood characteristics of river Tisza. The negative correlation between local population size at Bodrogzug PL site and maximum water level of Tisza River indicates that the higher the flood level, the less area is available for birds to nest in this site. The contrasting patterns between Bodrogzug PL site (population decline) and the other three local populations (population increases) suggest that many of the birds that had been driven out from the floodplain meadows at Bodrogzug PL site appeared in the other parts of the studied area in the years with inundation (time period 2). Unfortunately, there are no bird ringing results to confirm the movement of individuals between sites.

Factors triggering long-distance movements and distribution of Corncrakes within one breeding season are poorly revealed (Koffijberg *et al.* 2016), although searching for suitable breeding sites for a second brood and/or after disturbance by mowing might initiate such movements (Green *et al.* 1997, Schäffer & Koffijberg 2004). Our study provides a good example of the direct effect of flood on Corncrake distribution in Hungary, a phenomenon that has been suggested to operate on a much larger scale in some other parts of Europe (Mischenko & Sukhanova 1999, Koffijberg & van Dijk 2001). Due to the large mobility of Corncrakes within and between breeding seasons (e.g. van den Bergh 1991, Bürger *et al.* 1998, Koffijberg *et al.* 2016), floods may have an impact on geographically distant Corncrake populations, especially when they affect large numbers of Corncrakes, e.g. in the core breeding areas in Russia. For instance, Koffijberg and van Dijk (2001) assumed in their study

that the influx of Corncrakes in the Netherlands in 1998 was due to immigration from Belorussian and Russian populations, where the high water tables and floods hindered breeding in the floodplains. Similar effects of distant floods could also not be excluded in Hungary (Boldogh *et al.* 2009). Our results confirm that local populations need to be monitored simultaneously (all sites in all years), and they also suggest that the data from monitoring of the local populations have to be evaluated with consideration to their interrelationships.

Our study also shows that floods can have contrasting effects on Corncrake populations. On one hand, floods often have important positive effects on maintaining suitable vegetation at the breeding sites (Schäffer & Koffijberg 2004), and can delay the start of mowing that may threaten nests in floodplain meadows. On the other hand, a delayed retreat of floodwaters may be disadvantageous for Corncrakes, because this species prefers and tolerates much drier habitats than other Rallidae (Schäffer 1999). Our results show that this can happen in different years at the most important breeding site in Hungary (Bodrozug PL site, time period 2). Long periods of flooding at this site are partly a result of human activities (Figure 3). Due to the impact of a hydroelectric dam at Tiszalök, the retreat of floods is 2-2.5 times slower in this section of the river than in upper or lower reaches. Our data show that the dense, concentrated local populations of Corncrakes, as well as the populations of other grassland birds, are highly vulnerable to floods and other threats in this part of the floodplain. In fact, in years of flooding, the birds can not find breeding places here at all, or they have to move elsewhere, presumably leaving behind their nests.

This pattern of redistribution should be considered in designing Corncrake conservation measures in the region. Our data suggests that in order to reduce the negative impact of floods and improve protection of Corncrakes, it is highly important to maintain suitable alternative breeding places outside floodplains. Because the intensity and the methods of land use are key issues in the conservation of Corncrake populations (Green & Rayment 1996, Schäffer & Green 2001, Schäffer & Koffijberg 2004), the extension of favourable grassland management (e.g. Schäffer & Weisser 1996, Green *et al.* 1997) to the unprotected and unsupported areas is justified by our results. According to recent studies (e.g. O'Brien *et al.* 2006, Beaumont & England 2016), the conservation management schemes have clear benefits to Corncrakes. The implementation of allowance guidelines and measures (c.f. Sztahura & Rezneki 2015) that enable Corncrake-friendly management on HNVA (e.g. supervising by national park directorates, delayed mowing, obligatory use of game-repellent chains when mowing, adequate mowing directions, leaving unmown areas) would likely lead to a more favourable conservation status of Corncrakes (Faragó & Szentirmai 2014, Boldogh *et al.* 2016). Our results also implicitly suggest that an extension of the areas managed in bird-friendly ways and subsidised under the HNVA programme was necessary in NE Hungary for the effective protection of Corncrakes. Previously, less than 25% of known Corncrakes were in ESAs in different years (Boldogh *et al.* 2009), whereas this number increased to about 70% after the redesign and enlargement of this area by 35 000 ha in the HNVA programme (Figure 4). We believe that the extension will be a significant step forward in Corncrake conservation in NE Hungary.

Our results also suggest that further direct human impacts (e.g. building of a new dam on river Bodrog) and climate change may have serious negative impacts on Corncrakes

in the studied region and in Hungary. Climate change projections suggest a complete restructuring of the annual distribution of precipitation, as well as an increase in heavy precipitation events and severely increased peak river discharges and floods (Christensen & Christensen 2004, Bartholy *et al.* 2007, Kyselý & Beranová 2008, Bartholy *et al.* 2009, Rakonczai 2011). Therefore, the breeding possibilities of Corncrakes may become more limited in riparian meadows in the future. Hence, the importance of suitable breeding habitats outside flood-affected areas will probably grow in the near future and these habitats thus deserve an adequate conservation strategy. This is also because there is a risk that many of these grasslands will be converted to arable lands or will be abandoned and exposed to succession and invasive plants, which will generate conditions that are suitable neither for diverse wildlife nor for Corncrakes.

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