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Habitat selection of the Great Bustard *(Otis tarda)* in Körös-Maros National Park

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Abstract We investigated relationships among bustard presence data as response as well as properties of habitat patches such as shape, size, type of land use and landscape connectivity in 2015, employing bustard occurrence data in Körös-Maros National Park (KMNP hereafter). Additionally, we aimed to present a geometrical approach of habitat choice in animals, focusing on geometric properties rather than vegetation structure. Here we applied landscape metrics approach, providing landscape classification by analysing spatial patterns in potentially important landscape objects, disregarding linear constructions. Our findings show insignificant differences between shape metrics of selected and non-selected habitat patches, in line with previous studies concluding that bustards choose habitats based on habitat type classes rather than on geometric properties. Further, our results indicate that the original habitats of the study species, adapted to extensive, open steppes, became strongly fragmented, resulting in the absence of large contiguous areas. Within the study area, landscape connectivity values represent optimal habitat conditions, probably as a result of highly patchy structure of the landscape and relatively small nearest neighbour distances of habitat patches. Thus, our findings also indicate that Great Bustards adapted to modified landscape structures. Our landscape analytical approach provides a methodological framework which can be applied on habitat selection tactics in a number of species of key conservation importance.

Keywords: Great Bustard, landscape metrics, habitat patch, land cover, CORINE

Összefoglalás A túzok (*Otis t. tarda* L.) élőhelyválasztása és az élőhelyfoltok alakja, mérete, művelési ágankénti összetétele és táji szerkezete közötti összefüggéseket vizsgáltuk 2015-ös előfordulási adatok alapján a Körös-Maros Nemzeti Park területén. A vizsgálat célja egy olyan módszer bemutatása, mely a fajok élőhelyeinek nem növényzeti jellegű összetételére koncentrál, hanem annak geometriai sajátosságai közötti összefüggéseit vizsgálja. A vizsgálatokat a tájmetria eszköztárával végeztük, amely a tájat alkotó elemek területi mintázatának elemzésével ökológiai alapú tájleírást tesz lehetővé. A tájban vizuálisan elkülöníthető egységek számszerű vizsgálatával foglalkozik, amely minden esetben egy adott felszínborítási kategória összefüggő területrészleteit tartalmazza, zavaró vonalas létesítmények nélkül, létrehozva így a legrészletesebb folttérképet. Az eredmények azt mutatják, hogy a vizsgálati területen nincs szignifikáns különbség az élőhelyül választott területegységek alaki tényezőjében. A térségben a túzok területválasztása nem az alaki mutató függvénye. A vizsgálat eredményei alátámasztják, hogy az eredetileg nagy, nyílt sztyeppei területeket kedvelő faj élőhelyei feldarabolódtak, a nagy összefüggő felszínborítási formák megszűntek. A megfigyelések 90%-a 10 és 300 hektár közötti élőhelyfoltokra esik, annak ellenére, hogy 300 hektárnál nagyobb, összefüggő tájfoltok is rendelkezésre állnak. A vizsgálati területen az összefüggőségi értéke kiváló létfeltételeket számszerűsít, melyet a táj rendkívül mozaikos jellege és a tájfoltok egymáshoz viszonyított kis távolsága okozhat. Ezek alapján kijelenthető, hogy a vizsgált populáció nem egy maradványterületen, hanem a faj számára kiváló létfeltételeket biztosító kultúrtájban él. A túzok tehát viszonylag jól alkalmazkodott a megváltozott természeti körülményekhez, amely fennmaradásának alapját jelentheti. A kutatás kiterjesztésével más élőhelyekre, több évre visszamenő adatsorok vizsgálatával lehetőség adódik különböző adottságú életterek egymással való összehasonlítására, mellyel további értékes, a faj nemzetközi megmentését célzó intézkedések meghozatalára nyílhat lehetőség.

Kulcsszavak: túzok, tájmetria, élőhelyfoltok, felszínborítás, CORINE

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Introduction

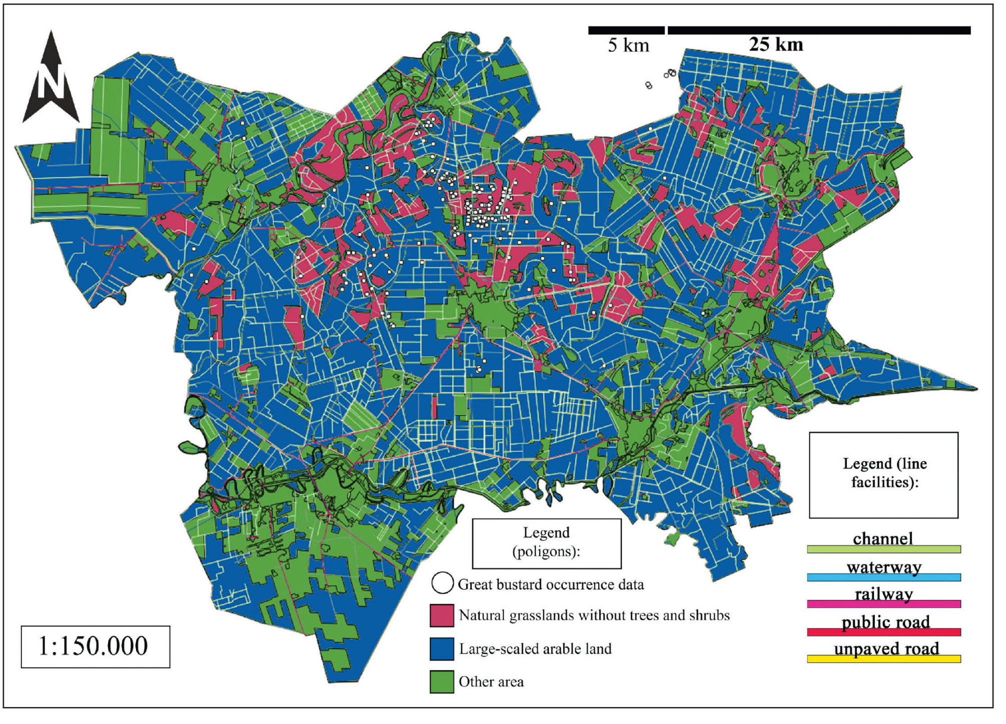
Human landscape modification activities are known to cover several milennia, showing high variance in different historical periods. These processes also substantially modified the landscape composition of the current area of Hungary. One of the most influential projects was represented by water regulation programmes aiming at converting natural habitats into agricultural areas, supposed to significantly influence habitat availability for the Great Bustard *(Otis tarda)*, recognised as an emblematic bird of Hungarian conservation.

The Great Bustard *(Otis tarda)* is a bird of key conservation concern distributed in the Eurasian steppe zone, and classified as an endangered flagship and umbrella species of steppe habitats (IUCN 2016). Significant part of the Central-European population of the Great Bustard is found in Hungary (Sterbetz 1979, Alonso & Palacín 2010, Alonso 2014), where the primary role of Great Bustard conservation is represented by Körös-Maros National Park, where 40% of the Hungarian population aggregates. Similarly to other regions within its distribution, bustards prefer agricultural areas providing food and potential nest sites in larger quantities than in seminatural habitats: from the 1960s onwards, formerly extensive agricultural areas turned into industrialised farmlands with increased use of pesticides, fertilisers and soil chemicals (Fatér & Nagy 1992, Faragó *et al.* 2014). Amplified by the country-wide ploughing and forestation of grasslands, this process led to significant changes in landscape structures which presumably forced bustards to occupy intensively cultivated areas, considered as suboptimal habitats. This led to the formation of smaller, closed and isolated populations, many of which have disappeared during the past few decades. This pattern was also amplified by the effects of high voltage electricity lines (Lóránt & Vadász 2014). During the late 1970s, agricultural intensification accelerated, including regions in East-Hungary harbouring the largest bustard populations. Additionally, the Hungarian population was further affected by harsh winters during the mid-1980s. Thus, agricultural areas functioned probably as ecological traps, whilst bustards were attracted to microclimatic conditions and improved food availability of these habitats during reproduction. However, the timing of first and second alfalfa harvests, hay-cutting, and autumn wheat harvest coincide with primary and supplementary broods of the Great Bustard. Further, the prescriptions of bustard-friendly agricultural programmes do not fully comply with the ecological characteristics of bustard breeding (Németh *et al.* 2009).

Here we apply landscape geometrical approach to identify key area and shape properties of habitats important in driving habitat selection tactics of the Great Bustard. We aim to find landscape properties to inform conservation management focusing on bustard-friendly agricultural schemes.

Materials and Methods

Our study was conducted in Dévaványa-Ecseg area of KMNP between January and October in 2015. Our dataset includes EOV coordinates (D72/EOV EPSG:23700) of observed bustards as well as date and time of the observation, recorded by the staff of KMNP Directorate, using handheld GPS. As the birds were not individually identifiable, the same location might refer to multiple observations. All locations were assigned to digitized polygons of habitat patches. As a base map, we used the 1:50,000 scaled habitat map available by the Institute of Geodesy, Cartography and Remote Sensing (http://www.nyme.hu/22677.html?&L=4), which identifies 80 land use types. In addition to bustard location points and the CLC50 shape files, we included shape files of dykes, roads, unpaved roads, landscape protection areas, nature reserves and railways as potential environmental predictors in further analyses. In total, the 967 polygons were cropped into 2816 polygons by artificial linear structures *(Map 1)*. In 2015, 224 observation points were recorded, 10 out of which were located outside of the boundary of the selected settlements. Thus, we obtained 77 polygons identified by 214 observation points *(Map 1)* and using their attribute tables, we calculated the following spatial metric of each polygon: (1) area, (2) perimeter, (3) ratio of perimeter and area (SI = shape index hereafter), (4) includes or excludes bustard observation point, (5) habitat type. Only for polygons with bustard observations, we included season. Next, we calculated landscape connectivity index, which aims at assessing the relationship between



Map 1. Detailed area coverage of the study area with bustard occurrence data
1. térkép A vizsgálati terület részletes felszínborítása a túzok előfordulási adatokkal

landscape structure and ecological needs of a particular species. To do so, we employed the patch cohesion index (PCI hereafter) *(Figure 1)* (Opdam *et al.* 2003, Szabó 2009, Pătru-Stupariu *et al.* 2017). By definition, PCI is not significantly different from zero in areas where ecological processes important for the study species are limited, whereas undisturbed landscape ecology provides PCI = 100 values. In other words, this metric approaches 0 as the proportion of the landscape comprised of the focal class decreases and becomes increasingly subdivided and less physically connected (Pătru-Stupariu *et al.* 2017). Spatial statistics were computed using ArcGis 9.2 (ESRI, Redlands, CA, 2006).

$$COHESION = \left[1 - \frac{\sum_{j=1}^{n} p_{ij}}{\sum_{j=1}^{n} p_{ij}\sqrt{a_{ij}}}\right]\left[1 - \frac{1}{\sqrt{A}}\right]^{-1} \times 100$$

Figure 1. Determination of Cohesion Index (Szabó 2009), where pij: circumference of ij spot, aij: area of ij spot, A: total area

1. ábra A kohéziós index meghatározása (Szabó 2009), ahol pij: ij folt kerülete, aij: ij folt területe, A: összterület

Results

Shape indices

Large-scale arable fields covered 63.5% of the total of the study area. Considering polygons including bustard observation points, bustards were detected in 52 large-scale arable fields out of the 77 polygons (67.5%). Bustard presence is strongly related to the total area of large-scale arable fields (χ^2-approximation of Kruskal-Wallis-test, df=1, $\chi^2 = 35.46$, $p < 0.0001$). Out of this, 19 polygons are classified as natural grasslands without trees and bushes (24.7%), contrasting the 10% cover of this habitat type within the total study area. Bustards selected these two habitat types in 92.2% of the observations.

The shape index of polygons including bustard points amounted to SI = 0.006, whereas for those without bustards SI = 0.004. Considering seasonality, SIwinter = 0.006, SIspring = 0.005, SIsummer = 0.006, SIautumn = 0.004. We found a significant relationship between polygon selection (yes or no) and shape index: shape index of polygons selected by bustards were significantly lower, showing a preference for more compact polygons with relatively small boundaries (χ^2-approximation of Kruskal-Wallis, $\chi^2 = 71.523$, $p < 0.0001$).

Habitat selection

In total, polygons covered 46 hectares in average (N = 2816), owing to the high density of abandoned dykes. Out of this set, polygons including bustard observations had an average area of 157.1 hectares (N = 77), 10.4% of which had areas exceeding 300 hectares (N = 8). Further, areas of 1.35% of the total polygon set was less than 300 hectares and the areas of 41 polygons exceeded this limit.

Considering land use types, bustards tend to prefer large-scale arable fields (N = 77, representing 67.5%) over natural grasslands without trees and bushes (χ^2-test, $\chi^2 = 0.676$, df

= 1, p = 0.418). Interestingly, majority of polygons including arable fields were located in the close proximity of grassland areas, which warrants further analyses considering this spatial relationship.

Landscape connectivity

Considering all N = 77 polygons, we calculated PCI = 99.94, suggesting optimal landscape connectivity conditions, indicating a highly patchy habitat structure and low mean neighbour distance of suitable habitat polygons.

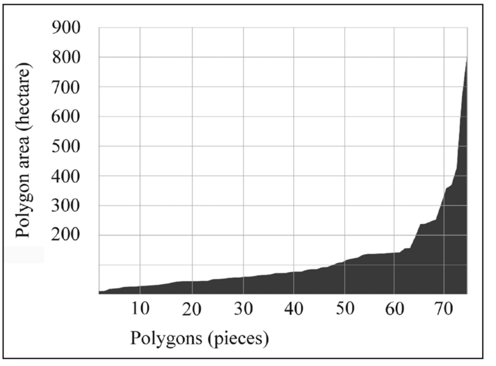


Figure 2. The distribution of the average area of the polygons observed with the Great Bustards

2. ábra A túzokkal megfigyelt poligonok átlag-terület eloszlása

Discussion

A number of studies reported that the Great Bustard has successfully adapted to cultural landscapes created by human-induced changes in land use (Alonso & Palacín 2010, Alonso 2014, Janó & Végvári 2016). However, bustards experience dramatic population declines at longer temporal scales, as a result of habitat loss due to intensification and industrialisation of agricultural technologies. In contrast, the ratio of the cover of agricultural areas and grasslands selected by bustards is close to 1:1 (Fatér & Nagy 1992).

Based on the results of the first and second Hungarian Great Bustards surveys carried out in 1985 and 1986, the ratio of bustards breeding in autumn wheat, legumes and grasslands were found to be approximately equal (Faragó 1990). However, based on the habitat type of saved broods, 49.44% of eggs were found in alfalfa, which is probably related to the intensity of agricultural management.

Our findings thus imply that bustards show no preference for contiguous areas exceeding 300 hectares, not considering artificial linear objects (paved and dirt roads, railway lines and dykes). Although large, contiguous habitat patches of the study species – formerly typical bird of extensive open steppes – became highly fragmented, it would find suitable habitat patches larger than 300 hectares.

As the Great Bustard is highly mobile and classified as partial migrant in Central Europe irregularly migrating to the Mediterranean region in harsh winters, it would be able to find larger contiguous habitat patches. This suggests that majority of the Hungarian population does not need habitats of this size.

The Great Bustard has adapted to the relatively high cover of arable lands within the study region, by preferring agricultural areas over grasslands even if grassland is available in its vicinity. Such habitat structures are available within the framework of agri-environmental schemes. This allows agricultural activities supported by the state which involves priorities for the ecological needs of bustards, by providing subsidies for farmers with decreased incomes as a result of bustard-friendly agricultural management. This framework thus supports bustard-specific agricultural management in key bustard regions, which might be extended to other key bustard regions, including Kiskunság region and North-West Hungary, where this system is not yet implemented, preferably during the next legal extension of agri-environmentaly schemes focusing on bustard conservation.

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