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Ancient Burial Mounds – Stepping Stones for Semi-Natural Habitats in Agricultural Landscape

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Abstract. Recent agricultural intensification followed by land homogenization require for connectivity of remaining semi-natural habitats for biodiversity preservation. This study is the first attempt to assess the importance of Bulgarian ancient burial mounds (kurgans) as refuges for semi-natural vegetation and for the connectivity to other semi-natural lands based on remote sensing data. A set of 509 kurgans were selected and their main vegetation cover and the landscape within 200 m surrounding buffer were studied. The general kurgan characteristics as height and diameter of the base resemble dimensions reported for Ukraine and Hungary. Our results show the high level of kurgan isolation in Bulgaria. More than the half of the studied kurgans surroundings are occupied by over 75% of agricultural and urban or other artificial landscape. This finding emphasizes the kurgans' role for preservation of semi-natural habitats and their inhabitants. We highlight the importance of Bulgarian kurgans that save a cumulative area of semi-natural type equal to the 0.09% of the whole country territory. Kurgans could be treated as relictual landscape in highly modified matrix. The importance of kurgans for biodiversity conservation should encourage the local community to increase the education and activities for proper management ensuring their further protection.

Key words: fragmentation, habitat islands, isolation, kurgans, landscape heterogeneity, small natural features.

Introduction

Current tendency for creating large continuous agricultural lands unifies the landscape, resulting in structural and functional homogenization (Benton et al., 2003; Gámez-Virués et al., 2015; Buhk et al., 2017), fragmentation of natural and semi-natural areas (Saunders et al., 1991), and habitat and biodiversity loss (Tilman, 1999; Williams et al., 2009). This fragmentation imposes difficulties for the species' populations to sustain and disperse through the surrounding homogenized matrix and to a pronounced edge effect, which suggests intrusion of more weeds from the adjacent arable fields (Hobbs & Yates 2003). The importance of small natural features has been emphasized for increasing heterogeneity (Tscharntke et al., 2002; Hunter, 2017). Yet, small natural features, especially when taken collectively, can also play an important role in biodiversity conservation and the provision of ecosystem services (Poschlod & Braun-Reichert, 2017). Semi-natural landscape elements in or around the crop fields such as hedges and vegetation strips serve as refuges for native species, as safe feeding areas for the fauna, and corridors for the movement of animals and dispersal of plants across a predominantly non-natural landscape (Benton et al., 2003). They also have the potential to positively influence the crop pollination as they attract pollinators and host them outside the crop flowering period (Wezel et al., 2014).

The ancient burial mounds (called also tumuli or more commonly kurgans) should be considered small semi-natural landscape elements as they are earth or earth-stone formations built from a local substrate. In the territory of Bulgaria numerous ancient burial mounds have been created as a result of the Yamna culture and Thracian civilization. The total number of kurgans in Bulgaria exceeds 50,000 (Kitov 1993) which rates the country at the forefront of kurgan numerosity in Europe together with Hungary and Ukraine (Deák et al., 2016b). The appearance of kurgans was dated back to the end of 4th millennium BC and their creation kept being a common practice in Thracian funeral rituals up to the 4th century AD, when the Christianity became a leading religion. These landscape features have been preserved for millennia both due to their historical, sacred and cultural significance and due to their steep slopes, being inappropriate for tillage (Fig.1). Recently there is growing interest about the conservation importance of kurgans for general plant diversity and steppe specialists preservation (Moysiyenko et al., 2014; Sudnik-Wójcikowska & Moysiyenko, 2012 ; Deák et al., 2016b, 2018, 2020). Several parameters of kurgans may affect their potential for maintaining semi-natural vegetation: size, degree of isolation from other semi-natural vegetation types and degree of woody plants encroachment (Deák et al., 2016a; Dembicz et al., 2016).

Fig. 1. Examples of Bulgarian kurgans, surrounded by agricultural land.
Photos by I. Apostolova and N.Velev.

This study is the first attempt to evaluate the importance of kurgans as small landscape features for the conservation of semi-natural habitats in Bulgaria. The objectives of this study are: (i) to provide general characteristics of Bulgarian kurgans, (ii) to assess the degree of their isolation and (iii) to assess to what extend their existence enriches the local semi-natural habitats.

Materials and Methods

Out of 50,000 kurgans reported by Kitov (1993) nearly 11,000 are included in the National Archaeological map with database (naim-bas.com/akb). We randomly selected a set of kurgans from this map occurring throughout the country and that have not been subjects of archaeological research (i.e. their vegetation was not destructed in excavation procedure) (n = 577). The geographic location and current presence of all selected kurgans was verified both by aerial photos using digital orthophoto map of Bulgaria (with accuracy 1.5 m, provided by Ministry of Agriculture, Food and Forestry) and topographic maps (in scale 1:5,000 and 1:10,000 elaborated by Geodesy, Cartography and Cadaster Agency). During this verification procedure, 68 kurgans were excluded from further analyses because their existence was not confirmed.

We created a GIS layer for remaining 509 , using ArcGIS version 10.3 (ESRI, 2014) in which they are represented as polygon features. Attributes such as geographic coordinates, altitude, area, vegetation cover and land cover type of surrounding areas were associated with each of them. The height of each kurgan was estimated as a difference between the altitude of their base and top isohypses. Their dimensions were calculated as a 2D areas in ArcGIS. We estimated visually the relative cover (%) of grassland and woody vegetation on the kurgans by satellite images available at Google Earth (google.com/earth). Kurgans with woody cover ≤ 10% were considered grassy (n = 176); kurgans with grassy cover ≤ 10% were considered woody (n = 115), and those with intermediate woody/grassy cover were considered mixed (n = 218). The 10% threshold was chosen to facilitate visual determination on Google Earth images.

We created a buffer area with a radius of 200 m bigger than that of the kurgan base (Fig. 2) and calculated the amount of natural versus non-natural habitats in the land cover within the buffer to estimate the degree of kurgans' isolation. A radius of 200 m was chosen to reflect the dispersal limitations of vascular plants considering the statement of Cain et al. (2000) that 100 m are a 'long distance' for seed dispersal. The land cover types in the buffer are taken from the database of the Land Parcel Identification System (LPIS), maintained by the Ministry of Agriculture, Food and Forestry. The LPIS is part of the Integrated Administration and Control System (IACS), which has been developed in all EU Member Countries in accordance with the main European Union (EU) and European Commission (EC) regulations. This database is kept up-to-date, because it is used to ensure that EU agricultural subsidy procedures are properly implemented. The land cover layer is with good spatial resolution, with minimum mapping unit 0.1 ha. The layer is digitized on the basis of deciphering a digital orthophoto map of Bulgaria. LPIS uses nomenclature of 37 land cover types, which we grouped into 6 categories: (1) urban and artificial areas, (2) annual crops, (3) perennial cultivation (perennial crops, orchards, vineyards), (4) forests, (5) grasslands, (6) other semi-natural land. For the purpose of this study, we defined categories 1–3 as non-natural and categories 4–6 as natural. The link between the original 37 LPIS land cover types and our six categories is available in the Appendix.

We then checked to what extent the kurgan is isolated from the surrounding habitat types. We gave different weight to each LPIS land cover type based on its potential to serve as source of propagules for the predominant habitat on the kurgan: 1 – LPIS land cover represents a habitat similar to the predominant habitat of the kurgan, and thus is a good potential source of propagules (e.g. pastures for the grassy kurgans, forests for the woody kurgans); 0 – the surrounding LPIS land cover types are very different habitats, or are not natural, and thus are not considered as a potential source of propagules for the predominant habitat on the kurgan (e.g. grasslands in the buffer get 0 for woody kurgans, and forests in the buffer get 0 for grassy kurgans; non-natural land cover gets 0 for both grassy and woody kurgans); 0.5 – the LPIS land cover type is a semi-natural habitat that has some potential to serve as a source of propagules for the predominant type of habitat on the kurgan (e.g. river banks in the buffer get 0.5 for woody kurgans, and wetlands in the buffer get 0.5 for grassy kurgans). Weights given to each LPIS land use cover are available in the Appendix. Then, the area of each LPIS land cover type in the buffer was multiplied by its weight and the resulting values were summed up and divided by the total area of the buffer. Resulting value we consider as a criteria of the propagule transferring ability of the surrounding buffer towards each particular type of vegetation on the kurgan. Since this ability is reversely proportional to the isolation, extracted from 100% the propagule transferring ability generates a value, which hereinafter we will call "degree of isolation".

Fig. 2. A buffer was created around each kurgan to assess the surrounding land cover types.

To test the importance of the kurgans as stepping stones, we reasoned whether and how much they increase the area of semi-natural vegetation cover in the buffer. We assumed that: (1) all analyzed kurgans are covered by semi-natural vegetation; (2) if they were not present, their 2D area would have been occupied by the same share of semi-natural vegetation (perceived also as habitats that are potential sources of grassy/ woody plant species) as the share in the buffer. Based on these assumptions, we calculated the area of three cover types in the territory of the buffer plus kurgans: (a) the area of semi-natural vegetation cover; (b) area of habitats that have the potential to provide diaspores of grassland plant species; and (c) area of habitats that have potential to provide diaspores of woody plant species. This calculation was conducted once with kurgan's data and once assuming no kurgan was there. We then used paired t-test to check whether the presence of the kurgan increase significantly those three areas.

Results

Majority of the studied kurgans (89%) is located in the lowlands and hilly-plains up to 600 m a.s.l. The average kurgans' height is 5.3 m ± 2.6 SD (min 1.9 m, max 18.6 m). Estimated 2D area of the kurgan foot ranges between 400 m^2 and 246 000 m^2 (average 2000 m^2 ± 500 SD). The territory around them is suitable for agriculture and the surrounding area of 270 kurgans (53%) is occupied by over 75% of agricultural, urban or other artificial areas (up to 25% naturalness) (Fig. 3).

Considering all studied kurgans, the prevailing number of them (i.e. 345 out of 509) have over 70% degree of isolation (Fig. 4a). Similar patterns are shown when we look at the subsets of grassy, woody and mixed cover kurgans (Fig. 4 b, c, d). On Fig. 4 it is clearly visible, that regardless of the vegetation type of the kurgans, the degree of their isolation from the buffer is high.

The presence of kurgans in a landscape increased the area of semi-natural vegetation by an average of ca. 1503 m^2 compared to a landscape of the same size but without kurgan (t = 3.158, p < 0.001, df = 508). Kurgans provided on average ca. 489 m^2 more forests in the landscape than in an area of the same size but without kurgans (t = 10.157, p<0.001, df= 508). The increase of the area of grasslands was about 1060 m^2 compared to a landscape of the same size without kurgans (t = 2.363, p = 0.009, df = 508).

When we multiplied the calculated average 2D area of the sampled kurgan set (2000 m^2) by the number of currently known kurgans in Bulgaria (Kitov, 1993) (n = 50 000), the resulting area became 100 km^2. According to the recent national statistics (Ministry of Agriculture, Food and Forestry , 2019), the total arable land with annual crops covers 34,616.15 km^2. Therefore we assumed that the kurgans in Bulgaria served for saving cumulative semi-natural area equal to 0.29% of this category or 0.09% of the whole country territory.

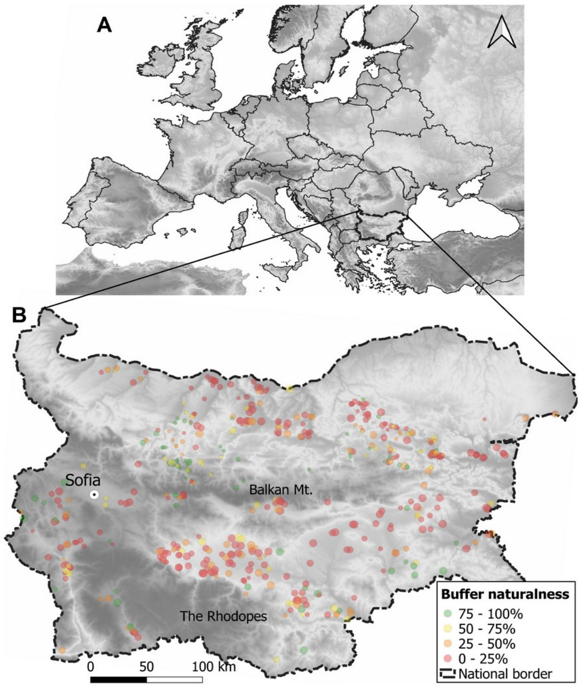

Fig. 3. (A) Study area. **(B)** Locations of the studied kurgans (n = 509). Point colors correspond to the share of non-natural habitats in the buffer, used as indicator of kurgan's isolation. Point symbol size indicates the 2D area size.

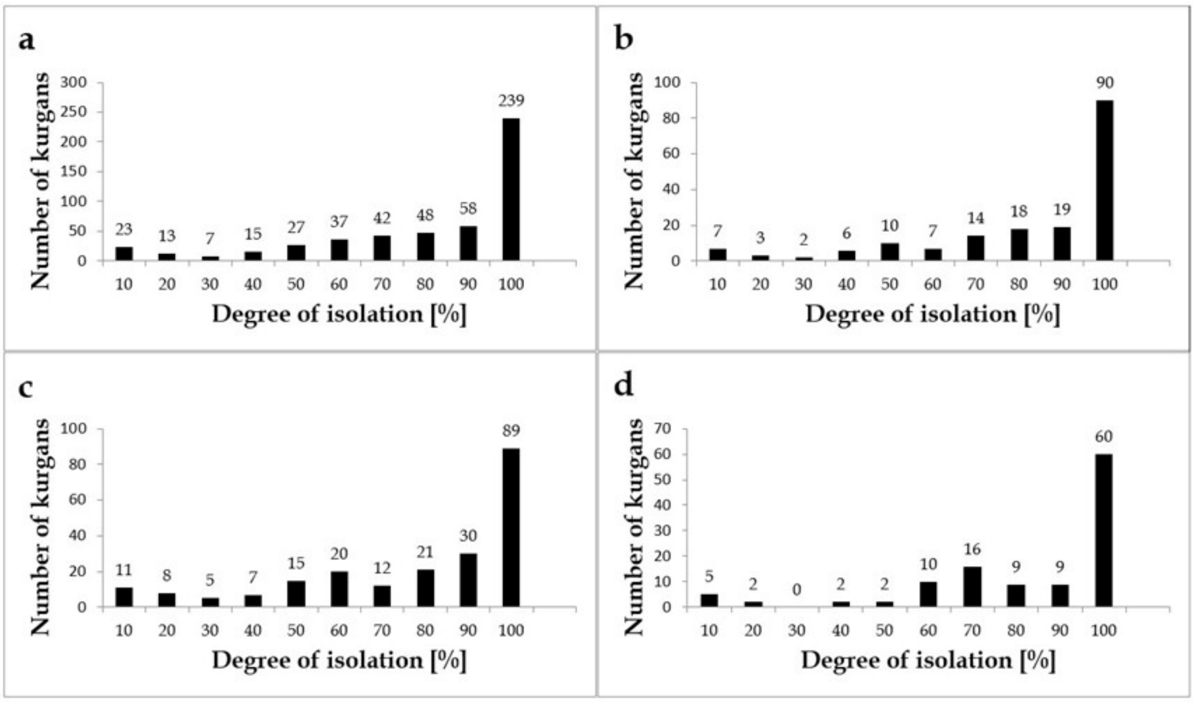

Fig. 4. Degree of kurgan isolation: **(a)** entire dataset (n=509); **(b)** subset of kurgans covered predominantly by grassy vegetation (grass cover greater than or equal to 90%; n=176); **(c)** subset of kurgans covered by mixture of woody and grassy vegetation (grassy cover greater than 10 and less than 90%; n=218); **(d)** subset of kurgans with a predominantly woody vegetation (grass cover less than or equal to 10%; n=115).

Discussion

Bulgarian kurgans have similar characteristics to Ukrainian and Hungarian ones regarding height and diameter (Sudnik-Wójcikowska et al., 2011, Deák et al., 2020). Our study revealed that the kurgan's presence within the landscape increases the share of semi-natural vegetation either grassland or woody. Their isolation from the neighboring natural or semi-natural habitats is significant and in many cases they are the only remnants of semi-natural habitats within the human modified areas. This supports the findings about the role of kurgans for maintaining natural species populations (Moysiyenko et al., 2014; Dembicz et al., 2016; Deák et al., 2016a, 2020). The cumulative importance of Bulgarian kurgans, regardless of their size but accounting their high frequency, is notable for the preservation of semi-natural landscape in the agricultural matrix. Where kurgans are surrounded by more than 95% agricultural and urban or artificial areas, they are the only territories which offer habitats for the native species (e.g. *Quercus pubescens*, *Ulmus minor*, *Stipa capillata*, *Adonis vernalis*, *Salvia nemorosa*, *Trifolium subterraneum* and many others). Therefore in the heavily homogenized agricultural landscape, same as other fragments of semi-natural character, the kurgans have a potential to serve as important sites for landscape diversification, biodiversity preservation (Tscharntke et al., 2002; Fahrig, 2003) and ecosystems functioning (Lindgren et al. 2018). In a predominantly non-natural landscape kurgans could also play an important role as stepping stones for plants and animals providing connectivity to remaining natural habitats (Dembicz et al., 2016). We consider here as stepping stone a semi-natural area, providing refuge for species survival and reproduction and facilitating their ability for dispersal in an inhospitable environment (Saura et al., 2013). The higher the share of non-natural areas in the kurgan surroundings, the higher its degree of isolation, and the higher the kurgan's importance as a stepping stone and its nature conservation importance.

Our observation showed that the vegetation cover of kurgans is diverse ranging from pure grasslands to forest. We don't have data about the management of Bulgarian kurgans, but considering that the potential natural vegetation of Bulgaria is forest (Bohn et al., 2003), the wooded kurgans exhibit a successional development in case of lacking management. The woody vegetation encroachment is traditionally considered as negative for the quality of grasslands (Eldridge et al., 2011; Deák et al., 2016a; Valkó et al., 2018). The established woody vegetation cover of some kurgans however, could be interpreted as favorable for overall habitat diversification in the agricultural matrix.

Considering the terminology introduced by McIntyre and Hobbs (1999), the kurgans could be regarded as 'relictual' habitats within destroyed matrix. Relictual habitats are the most threatened from further exogenous disturbances. Their conservation is pointed by McIntyre and Hobbs (1999) as an important goal for conservation activities and especially in the case of high levels of isolation these habitats should obtain a priority. The availability of small semi-natural landscape features within agricultural fields has been suggested as a promising solution for landscape preservation with a particular interest for biodiversity conservation also by Pe'er et al. (2017).

In Bulgaria historical monuments are protected by the Cultural Heritage Act, but the protection is not extended to their natural heritage, as it has been done for all kurgans in Hungary (Deák et al., 2016b). There is a deficiency of understanding in the society that kurgans are not only historical monuments but also important relictual habitats and this needs to be changed. Ratification of the European Landscape Convention (ETS No.176) by Bulgaria in 2004 obliges the country to apply appropriate procedures for local people and regional authorities' involvement in activities concerning kurgan existence (such as education programs, shrub clearing, alien plants removal) to preserve them as an integral part of the traditional landscape (Jones, 2007). Raising the knowledge about the natural value of kurgans, followed by adequate legal regulation will certainly improve the efficiency of their protection and preservation of the provisional, maintaining and cultural ecosystem services delivered by them.

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Appendix. Original land cover categories used in the national Land Parcels Information System (LPIS) and their interpretation for the current analysis.

LPIS code	LPIS description	Land cover category	Naturalness	Delivery propagules for kurgans:		
				woody	**grassy**	**mixed**
010	permanently cultivated land; arable land	annual crops	non natural	0	0	0
020	permanently cultivated land; permanent crops	perennial cultivation	non natural	0	0	0
021	permanently cultivated land; vineyards	perennial cultivation	non natural	0	0.5	0.5
022	permanently cultivated land; orchards with herbaceous vegetation among plantations	perennial cultivation	non natural	0	0.5	0.5
023	permanently cultivated land; aromatic plants plantations	perennial cultivation	non natural	0	0.5	0.5
031	kitchen garden	urban and artificial areas	non natural	0	0	0
032	urban territory near settlements	urban and artificial areas	non natural	0	0	0
040	permanent grasslands	grasslands	natural	0	1	1
041	natural meadows and pastures	grasslands	natural	0	1	1
043	grasslands situated within the forest territories usually in the mountain areas	grasslands	natural	0	1	1
050	agricultural lands with mixed land use	perennial cultivation	non natural	0	0	0
100	non cultivated land; mostly shrubland	other semi-natural land	natural	0.5	0.5	0.5
101	shrubland or grassland with scattered trees	other semi-natural land	natural	0.5	0.5	0.5
102	gullies and ravines	other semi-natural land	natural	0	0.5	0.5
103	non paved roads	other semi-natural land	non natural	0	0.5	0.5
200	forests	forests	natural	1	0	0.5
302	buildings outside the urban areas	urban and artificial areas	non natural	0	0	0
303	sport and leisure facilities	urban and artificial areas	non natural	0	0	0
400	water bodies and wetlands	other semi-natural land	natural	0	0.5	0.5
401	rivers and river beds	other semi-natural land	natural	0	0.5	0.5
402	lakes, dams and fens	other semi-natural land	natural	0	0.5	0.5
403	irrigation and drainage channels and associated land	other semi-natural land	non natural	0	0	0
404	water body near state border, icl. Danube river and Black sea)	other semi-natural land	natural	0	0	0
405	wetlands including mires	other semi-natural land	natural	0	0.5	0.5
500	disturbed lands	urban and artificial areas	non natural	0	0	0
501	mineral extraction sites	urban and artificial areas	non natural	0	0	0
502	dump site and tailing pond	urban and artificial areas	non natural	0	0	0
601	road with permanent pavement and associated land, including their transport facilities	urban and artificial areas	non natural	0	0	0
602	rail network and associated land, including railway facilities	urban and artificial areas	non natural	0	0	0
700	bare and eroded land	other semi-natural land	natural	0	0.5	0.5
701	sand, gravel and bare rock	other semi-natural land	natural	0	0.5	0.5
702	sparsely vegetated lands	other semi-natural land	natural	0	0.5	0.5
800	other territories	urban and artificial areas	non natural	0	0	0
801	small plot of non-arable land, with an area between 100 and 1000 square meters with non-agricultural permanent use.	other semi-natural land	natural	0.5	0.5	0.5
802	gorge – this type of territories are located in narrow river gorges when a river or railway passes along the river line or both. The territories include all sites, namely rivers and river beds, roads and/or railway lines.	urban and artificial areas	non natural	0	0	0
900	other areas forbidden for agricultural use - reserves, national security sites, etc.	other semi-natural land	natural	0.5	0.5	0.5