Ornis Hungarica 2016. 24(2): 32–45.
DOI: 10.1515/orhu-2016-0013

Nest site selection of the Great Bustard *(Otis t. tarda)* in Körös-Maros National Park, Eastern Hungary

Gizella Janó[1*] & Zsolt Végvári[1]

Received: October 18, 2016 – Accepted: November 30, 2016

Gizella Janó & Zsolt Végvári 2016. Nest site selection of the Great Bustard *(Otis t. tarda)* in Körös-Maros National Park, Eastern Hungary. – Ornis Hungarica 24(2): 32–45.

Abstract In the present study we aimed to identify factors influencing the spatial distribution of Great Bustard *(Otis t. tarda)* nests found between 1998 and 2015 in Dévaványa-Ecseg area in Körös-Maros National Park.
During the study period covering 17 years, we obtained information on 536 nests, which shows that Great Bustards used the following grassland crop types for breeding: wheat (43.07%), grassland (23.3%), fallow land (14.45%) and alfalfa (7.67%). These nests were found during the following activities: chemical weed control (33.63%), hay-cutting (25.37%), disking (8.55%) and harvesting (7.08%) and other 18 types of activities.
To identify the effects of disturbance and environmental factors on the spatial distribution of nests, such as distances to lek sites, roads, settlements and altitude, we formulated generalized linear models. As a result, we found that nest sites were significantly closer to lek sites and farther from human settlements than expected by random sampling.
Our results may contribute to the understanding of Great Bustard nest distributions, which can be helpful in nest detection prior to the initiation of disturbing agricultural activities, which is a key issue in the conservation of this bird. This study opens the way to analyse the effects of other environmental factors such as anthropogenic linear objects.

Keywords: R, QGIS, agricultural activities, Great Bustard conservation, nest site selection

Összefoglalás Aktuális kutatásunkban a Körös-Maros Nemzeti Park Dévaványai-Ecsegi puszták részterületén 1998 és 2015 között előkerült túzok (*Otis t. tarda* L.) fészkek elhelyezkedését befolyásoló külső tényezőket és a fészkek előkerüléseinek részleteit vizsgáltuk.
A vizsgált 17 évben 536 fészekről van információnk, ami az eddigi tanulmányokhoz hasonlóan azt mutatja, hogy a búza (43,07%), a gyep (23,3%), az ugar (14,45%) és a lucerna (7,67%) az elsődlegesen túzok fészkeket rejtő kultúrák. Ehhez kapcsolódóan pedig a fészkek vegyszerezés (33,63%), kaszálás (25,37%), tárcsázás (8,55%), aratás (7,08%) és további 18 tevékenység közben kerültek elő.
A statisztikai modellekkel a dürgőhelyek, utak, települések és szintvonalak esetleges hatását figyeltük, melyekből fészekcsészék helyzete és a dürgőhelyek kapcsolata között, valamint a fészekcsészék és a települések távolsága között szignifikáns összefüggést kaptunk. Előbbi pozitív, utóbbi negatív irányban tért el. Ezek alapján megállapítható, hogy ez a két külső tényező biztosan hatással van a túzokok fészkelőhely választásában.
Eredményeinkkel közelebb kerülhetünk a fészkek elhelyezkedésének megértéséhez, ami segíti a fészkek felderítését, még a zavarást okozó mezőgazdasági vagy egyéb munkák megkezdése előtt, ami a faj védelmének egyik záloga. Jövőbeli kutatási irányokként a környezeti tényezők hatásának további tanulmányozása és az egyéb ember által létesített vonalas építmények vizsgálata javasolt.

Kulcsszavak: R, QGIS, mezőgazdaság, túzok védelem, előfordulási gyakoriság

[1]*Department of Conservation Zoology, Hortobágy National Park Directorate – University 4024 Debrecen, Sumen utca 2., Hungary, e-mail: janogizella@gmail.com*
**corresponding author*

Introduction

The Great Bustard *(Otis tarda)* is a bird of key conservation concern distributed in the Eurasian steppe zone, which is also considered as an endangered flagship species, and as an umbrella species in its primary habitats (IUCN 2016). Majority of the Central-European population of this bird is located in Hungary (Sterbetz 1984, Alonso & Palacín 2010, Alonso 2014), where the primary role of Great Bustard conservation is represented by Körös-Maros National Park, as 40% of the national population is harboured in this region (I1). Therefore, the only Great Bustard Conservation Station in Hungary has been established here in 1978 (Czifrák 2014), followed by the operation of the largest Great Bustard conservation sample area in Central-Europe since covering 400 hectares (Széll 2005).

Research of this Great Bustard population has been initiated by Sterbetz and Faragó (Sterbetz 1975, 1976a, 1976b, 1984, 1986, Faragó 1983a, 1984, 1989, 1990a, 1990b, 1992a) during the 1980s and 1990s, showing the preference of Great Bustards for agricultural areas providing hypotheses to understand these processes (Sterbetz 1976a, 1980, Faragó 1983b, 1985a, 1985b, 1988).

Great Bustards breed in this region between late April to early August (Németh *et al.* 2009). During this period, a major and a supplementary nesting period can be distinguished (Faragó 2004). Nest site choice of the Great Bustard is primarily driven by a number of environmental factors (Alonso *et al.* 1998, 2004) such as distance to the nearest lek site (Osborn *et al.* 2001). Further, females show site fidelity to nest sites (Alonso *et al.* 2000), while another investigation showed that individually marked birds use all available potential nest sites independent of distance to the lek (Magaña *et al*. 2010).

Based on historical data, Great Bustards breed in native steppes (Stegman 1955). However, following the appearance of human agriculture, croplands rich in insects and providing optimal microclimatic conditions attracted Great Bustards for nesting (Bél 1737). Among natural and seminatural habitats, Great Bustards prefer to breed in alkali grasslands *(Achilleo-Festucetum pseudovinae)*, loess grasslands *(Salvio-Festucetum rupicolae)*, and Foxtail-grasslands *(Agrostio-Alopecuretum pratensis)* (Sterbetz 1976a). However, these habitats are often suboptimal due to to extremely wet or to extremely dry soil conditions. Thus, relatively high wheat and alfalfa plantations are more preferable during summer heat waves. Among available crops, females choose between fields based on the developmental state of crops during late April and early May (Fodor 1974a, 1974b, Faragó 1983c). Furthermore, Magaña *et al*. (2010) concluded that the most optimal nest sites of Great Bustards are characterised by vegetation cover high enough to provide a clear view on the surrounding areas or the nesting female which at the same time hide the bird, decreasing the probability of predation (Martín 2008). Besides, a number of previous studies have shown that habitat heterogeneity contributes to increased predation pressures driven by edge effects, whereas nest predation decreases with edge distance in homogenous habitats (Koivula *et al.* 1993, Chalfoun *et al.* 2002). Based on these conditions, wheat fields provide the most optimal nesting conditions combining visibility and decreased predation pressures. Further, microclimatic studies have indicated that alkali wet grasslands exhibit the largest amounts of variance in climatic parameters, due to large temperature and humidity extremities. Again, microclimatic conditions measured in wheat and alfalfa fields are significantly more stable (Faragó 1983c).

Our study aims to analyse the spatial distribution of Great Bustard nests in relation to various environmental and disturbance parameters, in order to inform conservation management in Dévaványa-Ecseg area.

To do so, in our investigation we applied spatial statistics for the identification of (1) potential nest sites which would inform conservation on the location of areas where nests would easier be found without disturbing incubating females, which might contribute to increased nest survival and (2) social (distance to lek site), environmental (altitude) as well as disturbance (distance to roads and settlements) parameters predicting the location of nest sites.

Materials and Methods

Our study is based on the database of Great Bustard nest records collected since 1998 in Dévaványa-Ecseg area of Körös-Maros National Park. This database were collected by members of the Ranger Service of Körös-Maros National Park Directorate, who collected these data from field workers such as hunters, agricultural tractor drivers, and other field workers, who called them to inform on Great Bustard's nest. Until 2004, only the year and coordinates of the nests were recorded. From 2005 onwards, these data are supplemented by area ID, settlement name, date, habitat and agricultural activity type. Additionally, since 2015, the size of the agricultural field, distance to field boundary, number of eggs, applied buffer zone, nest reoccupation event (yes or no), defecation event, located in outside or inside of the national park or SPA area.

To analyse relationships between the distribution of Great Bustards, we used the official spatial layers lek sites, public roads, settlements and altitude, provided by Körös-Maros National Park Directorate.

During the first step, we generated 5, 25, 50 and 95% occurrence probabilities of Great Bustard's nests, applying kernel density estimations fitted on nest coordinates. Kernel density estimation provides a contour plot of the two-dimensional histograms, which has been successfully applied in calculating animal breeding ranges.

During the second step, to compare the distances of random and actual nests from lek sites, settlements, roads and altitude, we formulated autologistic generalized linear models (GLM).

All statistical analyses were conducted in the R statistical programming environment (R Development Core Team 2016). Random point generation and spatial distance calculations were done using the „spatstat" specific package (Baddeley 2010). Breeding ranges were calculated and transformed into shape file format using the „maptools" (Lewin-Koh 2011) and „adehabitat" (Calenge 2006) packages. The resulting spatial datasets were visualised using the QGIS software (Quantum GIS Development Team 2016).

Kernel density estimates were used only to assess potential breeding areas and formed no part of the model formulation process. During the second step, to compare the distances of random and actual nests from lek sites, settlements, roads and altitude, we formulated autologistic generalized linear models (GLM). During the second step, to compare the distances of random and actual nests from lek sites, settlements, roads and altitude, we formulated autologistic generalized linear effects models, applying the „glm" function and entering the point type (random or real) as dependent variable, considering binomial family and logit-link (GLM).

Results

Between 1998 and 2015, we found a total of 536 nests in the study area *(Figure 1)*.

The majority of nests were found between 2011 and 2012, the number of which amounted to: mean n=33.1, sd=±10.45. Nests were discovered in municipality areas of 16 settlements: most of these were found in the district of Dévaványa, followed by those of Szeghalom, Ecsegfalva and Körösladány *(Figure 2)*.

Nest locations found between 1998 and 2015 are indicated in *Map 1*, which includes 509 nest locations.

Map 2 shows the 5, 25, 50 and 95% occurrence probabilites of Great Bustard nests. The application of 50% occurrence probabilities is especially useful in conservation practice as it is expected to increase the nest location probabilities of approximately 50% of nests during future nest searches, which allows the effective establishment of nest protection buffer zones, providing undisturbed habitats for rearing the chicks and thus contributing to the increased survival of the birds.

As a result of kernel density calculations, 5% breeding ranges size amounted to 1071 hectares, 25% range convered 7941 hectares, 50% range covered 23 326 hectares, while the 95%-os range covered 110 169 hectares.

Annual distribution of nest detections shows that major nest regions have shifted since the 1990s: whereas the area east of the settlement provided in several nests 17 years ago, most

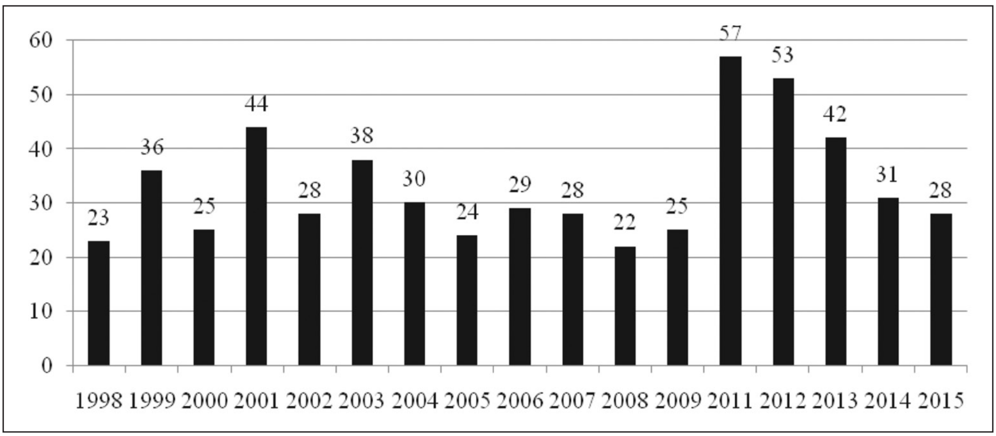


Figure 1. Annual numbers of the Great Bustard nest between 1998 and 2015
1. ábra 1998 és 2015 között előkerült túzokfészkek (db) évenkénti bontásban

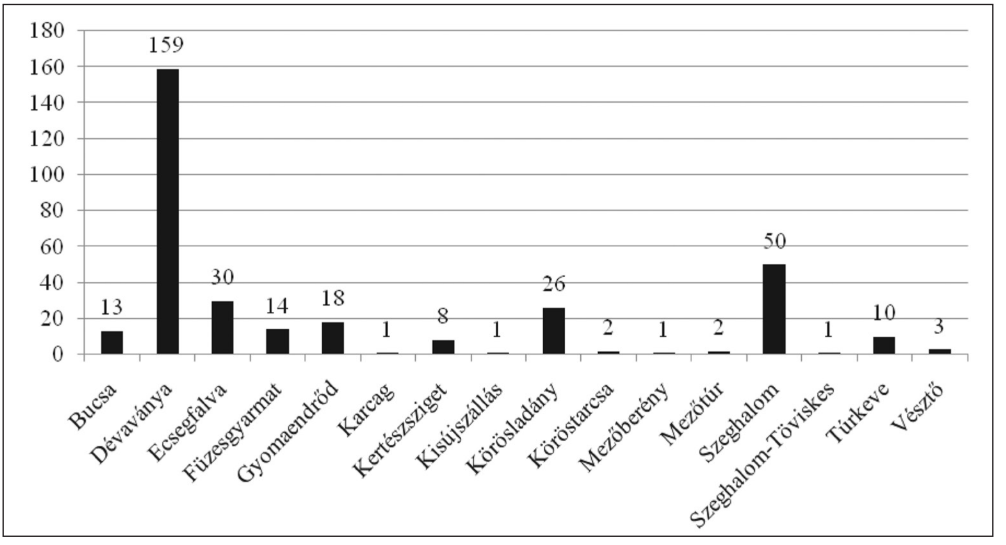
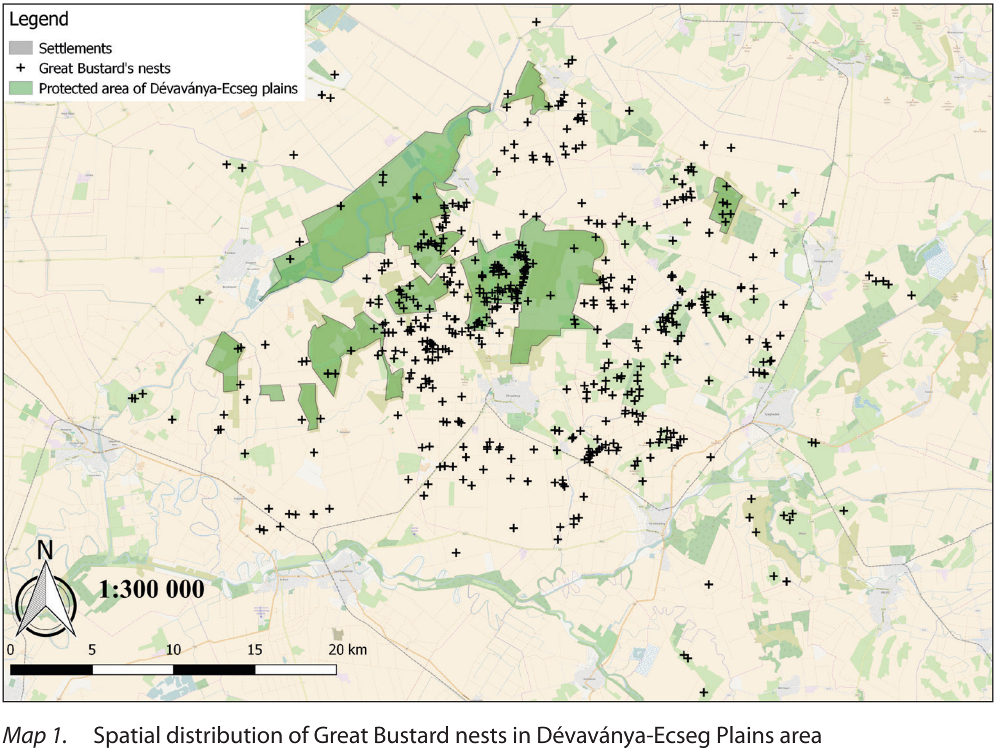


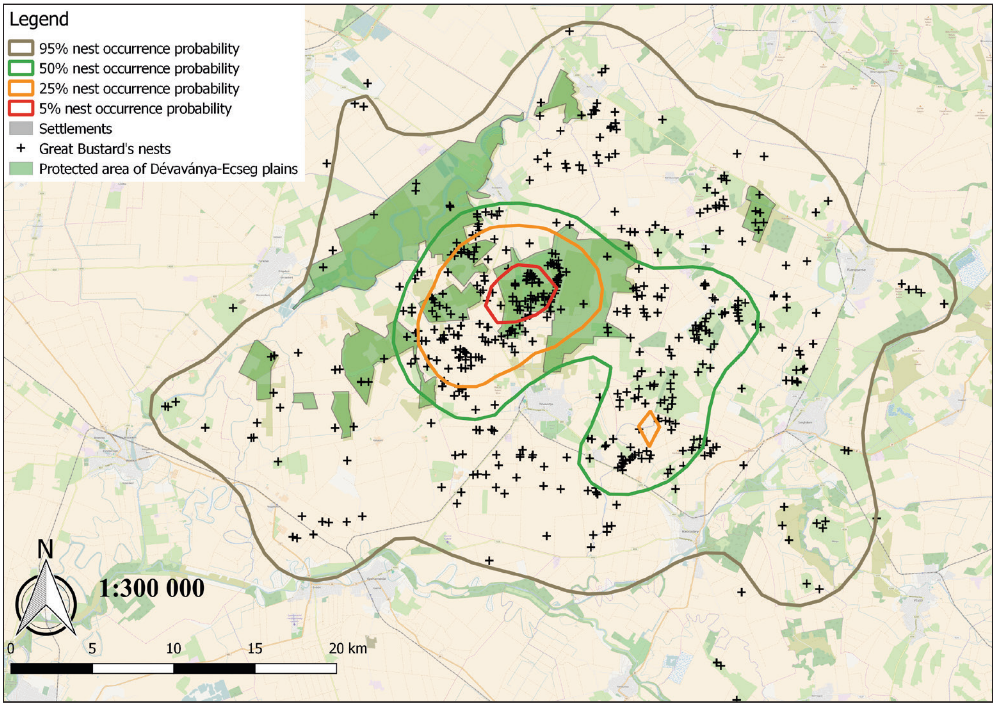
Figure 2. Settlements where Great Bustard nests were found during the last 17 years (nests/settlement)

2. ábra Települések, melyekről túzok fészkek kerültek elő a 17 év alatt (db/település)



Map 1. Spatial distribution of Great Bustard nests in Dévaványa-Ecseg Plains area

1. térkép A túzok fészkek előfordulása a Dévaványai-Ecsegi pusztákon



Map 2. 5, 25, 50 and 95% occurrence probabilities of Great Bustard nest
2. térkép A túzok fészkek előfordulási gyakoriságának 5%-os, 25%-os, 50%-os és 95%-os körzetei

of the eggs were found north-west of the town since the beginning of the 2000s. Based on nest frequencies, most of nests have been found in the central region of the study area and north of it. The 25% breeding range of nests includes an isolated patch, where caution is thus needed on female movements, when carrying out agricultural activities.

However, the intersection of annual 50% breeding ranges show a different pattern, exhibiting an area closer to Dévaványa and a clearly separated patch.

Considering the detection dates of nests, the earliest clutch was on 6 April 2014, while the latest clutch was discovered on 7 August 2006.

We possess information on 339 since 2004. During this period, we found 61 nests in April, 152 nests in May, 85 nests in June 40 nests in July and a single nest in August *(Figure 3)*.

Since 2004, nests have been found in the following habitat types, as ordered by decreasing importance: wheat (43.07%), native grassland (23.3%), follow land (14.45%) and alfalfa (7.67%), with a cumulative frequency of 88.49% *(Table 1)*. These 339 nests were found during 22 agricultural activities and other antropogenic disturbance processes. Majority of nests were discovered during chemical weed control (33.63%), followed by hay-cutting (25.37%) disking (8.55%) and harvesting (7.08%). During these operations, 74.63% of nests were discovered *(Table 2)*.

In 2015, 28 nests were found in total, 11 of which were located in the vicinity of Dévaványa, 6 near Szeghalom and 4 in Ecsegfalva *(Map 3)*.

Table 1. The Great Bustard nest's distribution by habitat types between 2004 and 2015
1. táblázat A fészkek élőhelyenkénti eloszlása 2004 és 2015 között

Habitat type	Quantity (piece)	Percentage (%)
Barley	6	1.77
Pea	1	0.29
Wheat	146	43.07
Canary grass	8	2.36
Alfalfa with grass	3	0.88
Cereal	2	0.59
Lawn	79	23.30
Lawn (farm place)	1	0.29
Ploughland overgrown with grass	1	0.29
Alfalfa	26	7.67
Sunflower	6	1.77
Rape	5	1.47
Stubble field	1	0.29
Triticale	1	0.29
Fallow land	49	14.45
Sowing grassland	1	0.29
Oat	3	0.88
All	339	100.00

Table 2. Reasons for finding Great Bustard nests between 2004 and 2015
2. táblázat A fészkek megkerülésének okai 2004 és 2015 között

Activities	Quantity (pieces/activity)	Percentage (%)
Harvesting	24	7.08
Direct nest searching	1	0.29
Mushroom picking	1	0.29
Ring rolling	1	0.29
Chamomile picking	2	0.59
Hay - cutting	86	25.37
Survaying before hay - cut	1	0.29
Observation	4	1.18
Combinatoring	2	0.59
Warren hunting	1	0.29
Transporting	18	5.31
Transporting, soil sampling	1	0.29
Cultivatoring	6	1.77
Grazing	8	2.36
Area pulling	1	0.29
Chemical fertilizer spreading	13	3.83
Smoothing	2	0.59
Stem-crushing	12	3.54
Disking	29	8.55
Area measurement	1	0.29
Dung spreading	1	0.29
Fallow landing	2	0.59
Hunting	4	1.18
Chamical spraying	114	33.63
Sowing	4	1.18
All	339	100.00

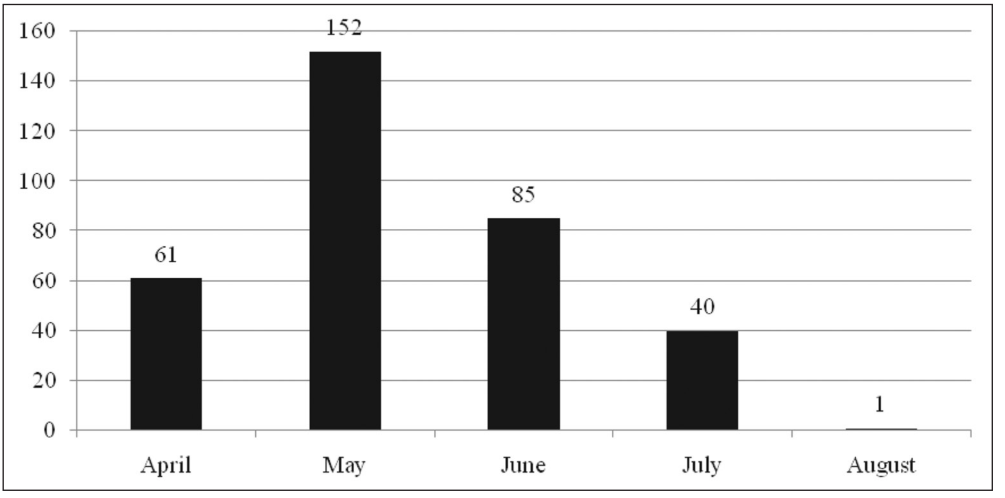
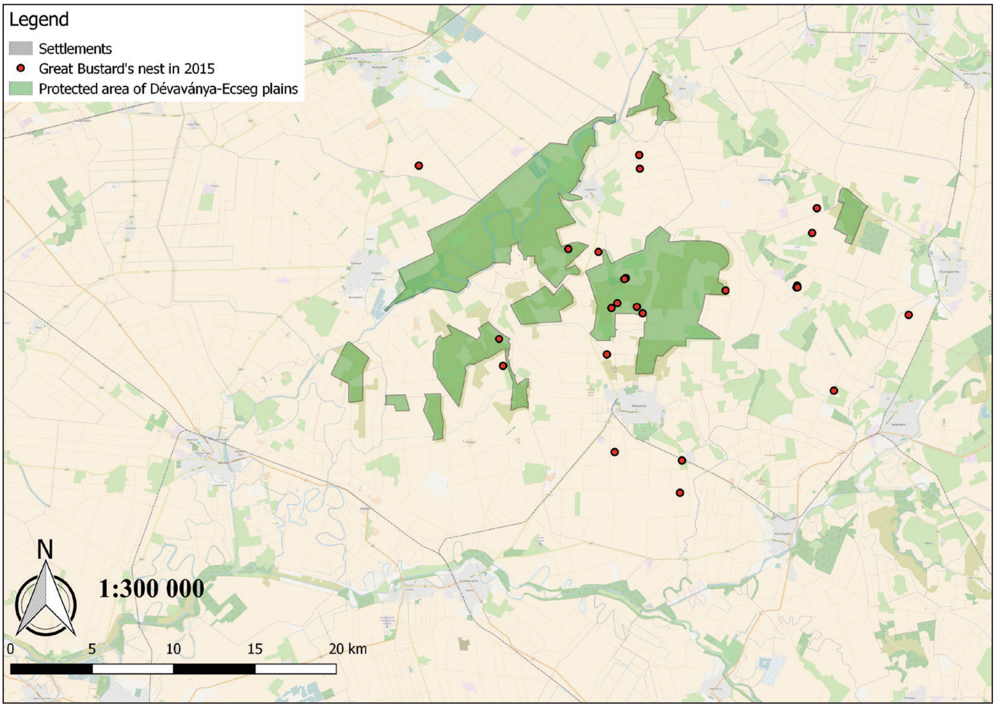


Figure 3. Monthly distribution of the Great Bustard nests' locations between 2004 and 2015
3. ábra A túzok fészkek előkerülése (db) havi bontásban 2004 és 2015 között

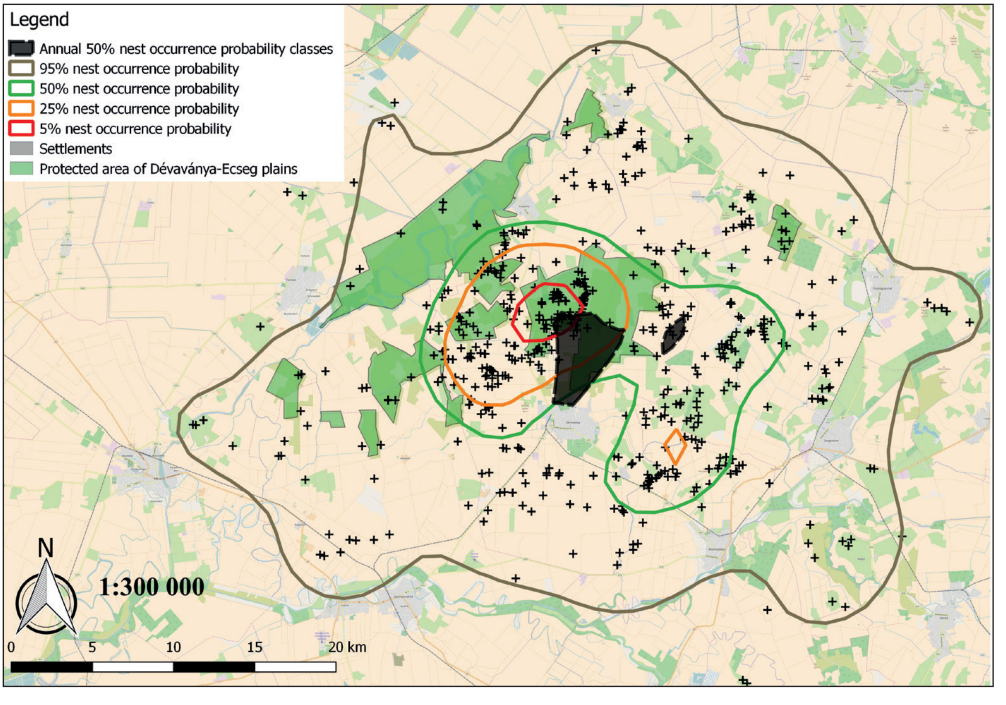


Map 3. Spatial distribution of Great Bustard nest in 2015
3. térkép A túzok fészkek területi eloszlása 2015-ben

In 2015, majority of nests were found in native grasslands (28.6%), followed by fallow land (17.8%), wheat (14.3%) sunflower (14.3%). Agricultural operations inducing disturbance are ranked in descending order of frequency as following: hay-cutting (39.3%), chemical pest control (17.9%) and cultivation (10.7%). Among these nests, 35.7% were found in fields of 5–20 hectares, 28.6% were located in a range of 50–100 hectares and 17.9% of nests were discovered in fields with size of less than 5 hectares. 14 (50%) of discovered nests were located within less than 100 metres from field boundaries, 13 (46.4%) were found in a range of 100–300 metres from field boundaries and a single nest was discovered (3.6%) farther than 300 metres from field boundaries. All nests included one or two eggs, 9 out of which (32%) included a single egg, while the remaining 19 nests contained two eggs (68%). Thus, average nest site amounted to 1.68 in 2015. Out of all discovered nests, 4 (14.3%) were not reoccupied by females, while 24 were reoccupied (85.7%).

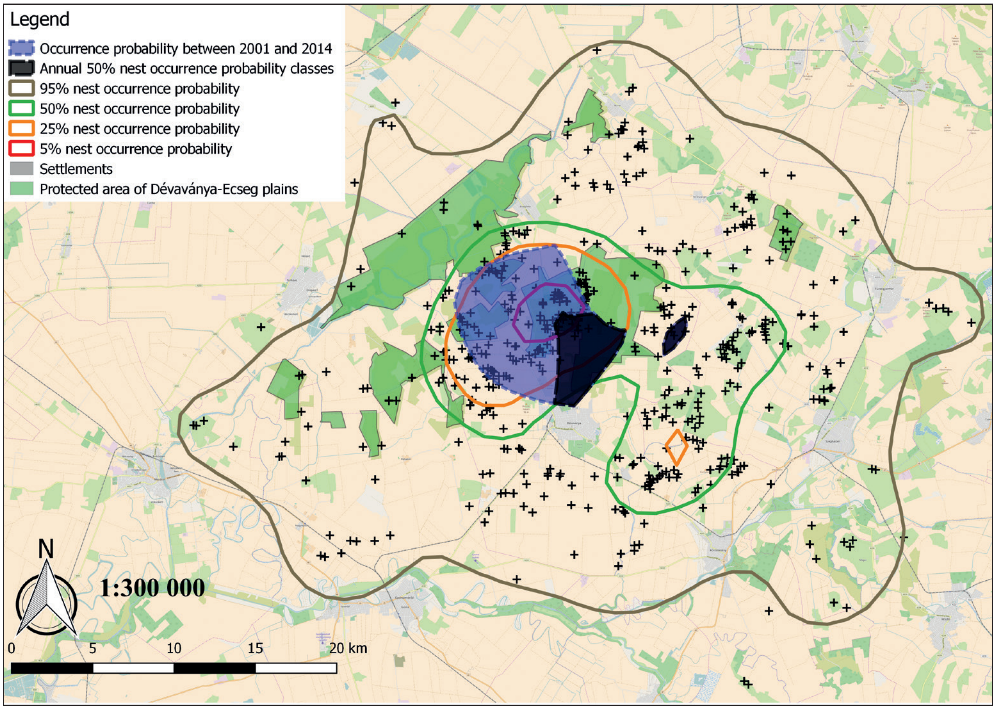
In four cases, protective buffer zones were not established (14.3%), while the size of the buffer zone was 10–50m^2 in a single case (3.57%), ranging between 50–200 m^2 in four cases (14.3%), between 200–700 m^2 in 12 cases, (42.9%), while this size exceeded 700 m^2 in seven cases (25%). Defecation into nest was observed in a single case (3.6%), while in the other 27 (96.4%) cases no such behaviour was detected.

Actual nest positions were significantly closer to lek sites than those of random locations (Kruskal-Wallis test $\chi 2=8.6039$; df=1, p=0.0033). Results of the autologistic model



Map 4. Spatial distribution of the Great Bustard nests with occurence probabilities and annual 50% probability classes

4. térkép A fészkek elhelyezkedése az előfordulási gyakoriságokkal és az évenkénti 50%-os gyakoriságok metszetével



Map 5. Spatial distribution of Great Bustard nests with breeding probability, annual 50% occurence probability cut between 1998 and 2015 and 50% occurence probability cut between 2001 and 2014, which recommended as Great Bustard nesting test area

5. térkép Az 1998 és 2015 között előkerült fészkek elhelyezkedése a fészkelési gyakoriságokkal, az évenkénti 50%-os gyakoriságok metszetével és 2001 és 2014 között a fészkek előfordulási gyakoriságának 50%-os metszetével, ami ajánlott túzokfészkelési vizsgálati terület is egyben

show that real nests were located significantly farther from settlements than random nests ($p=0.0007$). Contrary to our expectations, road distance and altitude exerted no effects on nest positions ($p=0.5639$ and $p=0.8608$, respectively).

Map 4. shows the intersection of annual 50% breeding range layers, which covers 1729 hectares.

Between 2001 and 2014, non-protected agricultural areas north and northeast of Dévaványa shows also a prefered territory by females. The intersection of these areas amounts to 6787 hectares *(Map 5)*.

Discussion

As compared to the past 30 years, agricultural habitats used for nesting include fallow lands in a large number of cases, besides wheat, grassland and alfalfa (Faragó 1985a, Morgado & Moreira 2000). Fallow lands are usually established in arable lands severely affected by rainy periods, resulting in temporary wetlands, especially in former oxbows and marshes of the region which makes agricultural operations impossible. Additionally, fields are increasingly set aside as a result of agricultural environmental schemes, the Great Bustard-friendly specific programme of which is also available in the study region (I2).

Agricultural operations causing disturbance represent the seasonal management of agricultural activities: majority of nests have been found in wheat fileds, during chemical wheat control which is a characteristic activity during the breeding period.

Considering the annual distribution of nest detections, the importance of distrubance types might vary substantially.

Based on literature resources, the clutch size of Great Bustards range between 1 and 3 (Fodor 1974b, Faragó 1983b, 1992b, Morgado & Moreira 2000). However, the average number of eggs was less than 2.0, which indicates the intensified conservation of Great Bustards, considering the low mean breeding success of females (Morales *et al.* 2002). In contrast, the frequency of nest desertion was rather low in our study, contrasting with an earlier study in Hungary (Demeter *et al.* 1994). However, we possess no data on breeding success, which would allow to test the effects of predation pressure in wild populations (Morales *et al.* 2002, Faragó *et al.* 2014). Nest location data from 2015 indicate that majority of nests were found close to field boundaries, which is probably a result of traffic disturbance and do not necessarily reflect real nest distribution patterns (Lane *et al.* 2001) However, if this pattern is a real element of Great Bustard nesting behaviour, then it might be beneficial for females by easier reaching various habitats from field edges, allowing an increased availability of wider diet spectra for females and the young, which might induce positive effects in population dynamics.

In contrast to our prior expectations, nest positions were not related to roads and altitude, while leks but not nests were found closer to lek sites (Burnside *et al.* 2013, Lóránt & Vadász 2014). Similar results were found by Osborne *et al*. (2001), which were not confirmed by further investigations carried out in Spain, elsewhere (Magaña *et al.* 2010). Therefore, this nest localisation study calls for future investigations carried out on satellite or radio-tagged birds.

The missing effects of roads on nest distributions might have been driven by sampling bias, as the real number of nests in various distances from roads are not sufficiently known.

However, if roads do not really affect nest positions, nest surveys need to include fields connected to public and dirt roads. Considering nest locations and frequencies found in 17 years, the focal nesting area of Great Bustards is situated north of Dévaványa.

The results of kernel density estimates show that nests have been detected during agricultural operations in areas necessarily far from settlements, but close to lek sites.

As most of the nests were found within the municipality area of Dévaványa, mostly in wheat, grassland, fallow land and alfalfa habitats, these habitat classes need to be primarily searched for Great Bustard nests. Additionally, the results of spatial statistics show that majority of nests might be found within a five kilometres range of lek sites and farther than four kilmoteres from settlements (Moreira *et al.* 2004). As females do not seem to avoid neither public nor dirt roads, fields adjoining linear objects are also recommended to be surveyed. These works are suggested to be started in April and to be continued in May, in order to obtain reliable data on Great Bustard movements prior to agricultural operations.

One of the key objectives of our study was to outline areas where the probability of finding Great Bustard nests is significantly higher than predicted by random search which thus allows the detection and protection of nests before agricultural disturbance.

To do so, further studies are required within possible hotspots. For nest surveys, we recommend to apply 50% breeding ranges, which by definition omit large areas with probable nest occurrence. Additionally, 50% breeding ranges indicate areas where no nests were detected during the past 17 years, which are close to settlements and predicted to be avoided by Great Bustards *(Map 4)*. This contradiction is a result of computing breeding ranges based on nest location only and not controlling for environmental and disturbance models in the same sets.

Based on our results, the isolated habitat patch needs to be surveyed which is indicated by both 25 and 50% breeding range intersections, located in non-protected agricultural areas north and northeast of Dévaványa. However, the intersection of these areas amounts to 6787 hectares, which is still too large for nest surveys.

Our study calls on further investigations on the effects of the spatial distribution of predation pressure and on spatial aggregation patterns of females during breeding (Fodor *et al.* 1971, Demeter 1995).

Such an integrated study would allow the formulation of complex models which would result in more precise maps of habitat use, resulting in more reliable approaches for nest surveys, which facilitates Great Bustard conservation.

Acknowledgements

We are grateful to the staff of Körös-Maros National Park Directorate, especially for Péter Bánfi, leader of the Department of Conservation and Project Management, who provided access to nest datasets and map layers as well as valuable comments on the investigation. Further, we owe many thanks to Tibor Lengyel and Antal Széll, members of the Ranger Service, who supported us during the whole of our Great Bustard conservation works.

References

Alonso, J. C. 2014. The Great Bustard: past, present and future of a globally threatened species. – Ornis Hungarica 22(2): 1−13. DOI: 10.2478/orhu-2014-0014

Alonso, J. C., Martin, E., Alonso, J. A. & Morales, M. B. 1998. Proximate and ultimate causes of natal dispersal in the Great Bustard, *Otis tarda*.−Behavioral Ecology 9: 243−252.

Alonso, J. C., Martín, C. A., Alonso, J. A., Palacín, C., Magaña, M. & Lane, S. J. 2004. Distribution dynamics of a Great Bustard metapopulation throughout a decade: influence of conspecific attraction and recruitment. − Biodiversity and Conservation 13: 1659−2004. DOI: 10.1023/B:BIOC.0000029329.44373.47.

Alonso, J. C., Morales, M. B. & Alonso, J. A. 2000. Partial migration, and lek and nesting area fidelity in female Great Bustards. − The Condor 102: 127–136.

Alonso, J. C. & Palacín, C. 2010. The world status and population trends of the Great Bustard *(Otis tarda)*: 2010 update. − Chinese Birds 1(2): 141−147. DOI: 10.5122/cbirds.2010.0007.

Baddeley, A. & Turner, R. 2010. spatstat: Spatial Point Pattern Analysis, Model Fitting, Simulation, Tests. − R package version 1−19.

Bél, M. 1737. Hungariae antiquae et novae prodromus III. [Old and new harbinger of Hungary]. − Norinburg (Nürnberg), XIV. 21. (in Latin)

Burnside, R. J., Végvári, Zs., James, R., Konyhás, S., Kovács, G. & Székely, T. 2013. Human disturbance and conspecific influence display site selection by Great Bustards *Otis tarda*. – Bird Conservation International 24: 32−44. DOI: 10.1017/S0959270913000142.

Calenge, C. 2006. The package "adehabitat" for the R software: a tool for the analysis of space and habitat use by animals. − Ecological Modelling 197(3): 516−519.

Chalfoun, A. D., Thompson, F. R. III. & Ratnaswamy, M. J. 2002. Nest predators and fragmentation: a review and meta-analysis. − Conservation Biology 16: 306–318.

Czifrák, G. 2014. Practice of incubation, rearing and repatriation at the Great Bustard Rescue Station of the Körös-Maros National Park Directorate. − Aquila 121: 133−136.

Demeter, L. 1995. The spatial distribution of Great Bustard *(Otis tarda)* nests in relation to solitary males in eastern Hungary. – Aquila 102: 53–60.

Demeter, L., Fatér, I. & Szép, T. 1994. The degree and cause of destruction of endangered Great Bustard *(Otis tarda)* nests in Hungarian populations. – Ornis Hungarica 4: 19−24.

Faragó, S. 1983a A talaj szerepe a túzok (*Otis tarda* L., 1758) elterjedésében és költésbiológiájában Magyarországon [The role of soil in Great Bustard (*Otis tarda* L., 1758) dispersal and breeding biology in Hungary]. – Erdészeti és Faipari Tudományos Közlemények 1: 75–89. (in Hungarian)

Faragó, S. 1983b A túzok *(Otis tarda)* fészkelés biológiája Magyarországon [Breeding biology of Great Bustard in Hungary]. − Állattani Közlemények 70: 33−38. (in Hungarian)

Faragó, S. 1983c A túzokkutatás legújabb eredményei Békés megyében, a békési túzok autökológiájának vázlata [The latest result of Great Bustard research in County Békés, outline of the Great Bustard's autecology]. – Környezet- és Természetvédelmi Évkönyv 5: 113−144.

Faragó, S. 1984. A túzok vizsgálata Magyarországon [Investigation of Great Bustard in Hungary]. – Erdészeti és Faipari Egyetem Kutatási Témái 3: 84–87. (in Hungarian)

Faragó, S. 1985a XI. Investigations on the nesting ecology of the Great Bustard (*Otis t. tarda* L., 1758) in the Dévaványa nature conservation district I. Comparative studies of microclimate I. – Aquila 92: 133−173.

Faragó, S. 1985b Túzokrezervátumok, túzoktelepek Közép-Európában III. Dévaványai Tájvédelmi Körzet Magyarország [Great Bustard Reservations and ranches in Central Europe III. Dévaványa Nature Conservation District in Hungary]. – Madártani Tájékoztató: 196–199. (in Hungarian)

Faragó, S. 1988. Investigaions on breeding ecology of Great Bustard *(Otis tarda)* in the Dévaványa Nature Conservation District II. Comparative study of food availability. – Aquila 95: 123–141.

Faragó, S. 1989. A mezőgazdaság hatása a túzok (*Otis tarda* L.) állományra Magyarországon [The impact of agriculture on the stock of Great Bustard (*Otis tarda* L.) in Hungary]. – Nimród Fórum (in Hungarian)

Faragó, S. 1990a A túzok Magyarországon [Great Bustard in Hungary]. – Venatus Kiadó, Szentendre, pp. 9–43.

Faragó, S. 1990b A kemény telek hatása Magyarország túzok (*Otis tarda* L.) állományára [The effect of heavy winters on Great Bustard (*Otis tarda* L.) populations in Hungary]. – Állattani Közlemények 74: 51–62. (in Hungarian)

Faragó, S. 1992a Adatok a kék színű túzoktojás kérdéséhez [Datas on the question of the blue-shaded Great Bustard egg]. – Aquila 99: 93–94.

Faragó, S. 1992b Clutch size of the Great Bustard *(Otis tarda)* in Hungary. – Aquila 99: 69–84.

Faragó, S. 2004. KvVM Természetvédelmi Hivatal Fajmegőrzési tervek, Túzok *(Otis tarda)* [MoEWR Nature Conservation Office conservation plans, Great Bustard *(Otis tarda)*]. – Környezetvédelmi és Vízügyi Minisztérium, Természetvédelmi Hivatal (in Hungarian)

Faragó, S., Spakovszky, P. & Raab, R. 2014. Conservation of Great Bustard *(Otis tarda)* population of the Mosoni-Plain – A succes story. – Ornis Hungarica 22(2): 14–31. DOI: 10.2478/orhu-2014-0015

Fodor, T. 1974a A túzokpopuláció létszámváltozása Magyarországon 1973-ig [Number fluctuation of Great Bustard population in Hungary until 1973]. – Aquila 80–81: 121–138. (in Hungarian)

Fodor, T. 1974b A túzok fészkelésbiológiája [Breeding biology of Great Bustard]. – A vadgazdálkodás fejlesztése 11. – Természetvédelem: 19–23. (in Hungarian)

Fodor, T., Nagy, L. & Sterbetz, I. 1971. A túzok [Great Bustard]. – Mezőgazdasági Kiadó, Budapest (in Hungarian)

IUCN 2016. Red List of Threatened Species. www.iucnredlist.org

Koivula, K., Lahti, K., Orell, M. & Rytkonen, S. 1993. Prior residency as a key determinant of social dominance in the Willow Tit *(Parus montanus)*. – Behavioral Ecology and Sociobiology 33: 283–287. DOI: 10.1007/BF02027126

Lane, S. J., Alonso, J. C. & Martín, C. A. 2001. Habitat preferences of Great Bustard *Otis tarda* flocks in the arable steppes of center Spain: are potentially suitable areas unoccupied? – Journal of Applied Ecology 38: 193−203. DOI: 10.1046/j.1365-2664.2001.00577.x

Lewin-Koh, N. J., Bivand, R., Pebesma, E. J., Archer, E., Baddeley, A., Bibiko, H. J. & Turner, R. 2011. maptools: Tools for reading and handling spatial objects. − R package version 0.8-10.

Lóránt, M. & Vadász, Cs. 2014. The effect of above-ground medium voltage power lines on displaying site selection of the Great Bustard *(Otis tarda)* in Central Hungary. − Ornis Hungarica 22(2): 42−49. DOI: 10.2478/orhu-2014-0017

Magaña, M., Alonso, J. C, Martín, C. A., Bautista, L. M. & Martín, B. 2010. Nest-site selection by Great Bustards *Otis tarda* suggests trade off between concealment and visibility. − Ibis 152: 77−99. DOI: 10.1111/j.1474-919X.2009.00976.x

Martín, B. 2008. Dinamica de poblacion y viabilidad de la Avutarda Comun en la comunidad de Madrid [Population dynamics and viability of Great Bustard in the community of Madrid]. − PhD thesis, Universidad Complutense de Madrid

Morales, M. B., Alonso, J. C. & Alonso, J. 2002. Annual productivity and individual female reproductive succes in a Great Bustard *Otis tarda* population. – Ibis 144: 293−300. DOI: 10.1046/j.1474-919X.2002.00042.x

Moreira, F., Morgado, R. & Arthur, S. M. 2004. Great Bustard *Otis tarda* habitat selection in relation to agricultural use in southern Portugal. −Wildlife Biology 10: 251–260.

Morgado, R. & Moreira, F. 2000. Seasonal population dynamics, nest site selection, sex-ratio and clutch size of the Great Bustard *Otis tarda* in two adjacent lekking areas. – Ardeola 47: 237−246.

Németh, Á., Lóránt, M. & Vadász, Cs. 2009. Mennyire tekinthető hatékonynak az Agrár-Környezetgazdálkodási Program túzokvédelmi célprogramjaiban szereplő előírások? [How effective are the management regulations of the Great Bustard Protection Agro-Environmental Program?]. – Természetvédelmi Közlemények 15: 226−234. (in Hungarian)

Osborn, P. E., Alonso, J. C. & Bryant R. G. 2001. Modelling landscape-scale habitat use using GIS and remote sensing: a case study with Great Bustards. − Journal of Applied Ecology 38: 458−471. DOI: 10.1046/j.1365-2664.2001.00604.x

Quantum GIS Development Team 2016. Quantum GIS Geographic Information System. – Open Source Geospatial Foundation Project. R Development Core Team 2016

Stegman, B. 1955. Endemizm v avifauna veraziszkih sztyepej [Endemism of the North Asian steppe's bird fauna]. − Pamjati Akademika L. sz. Berga, Moszkva (in Russian)

Sterbetz, I. 1975. A kelet-magyarországi túzok (*Otis t. tarda* L.) populációk területigényének alakulása [Developement of the eastern Hungarian Great Bustard (*Otis t. tarda* L.) popultions land use need]. – Aquila 82: 155−162. (in Hungarian)

Sterbetz, I. 1976a A túzok (*Otis t. tarda* L.) környezete Magyarországon [The environment of the Great Bustard *(Otis tarda)* in Hungary]. – Aquila 83: 53–73. (in Hungarian an English)

Sterbetz, I. 1976b Túzok-génbank Békés megyében [Genebank of the Great Bustard in County Békés]. – Környezet- és Természetvédelmi Évkönyv 5: 113–129. (in Hungarian)

Sterbetz, I. 1980. Comparative investigations into the reproduction behaviour of monogamous, polygamous and unmated Great Bustard populations in South-Eastern Hungary. – Aquila 87: 31–47.

Sterbetz, I. 1984. A magyarországi túzok (*Otis t. tarda* L., 1758) populációk életképességének vizsgálata 1971 – 1972 időközében [Study of the viability of Great Bustard (*Otis t. tarda* L., 1758) populations in Hungary 1971–1982]. – Aquila 91: 93–98. (in Hungarian and English)

Sterbetz, I. 1986. A magyarországi túzokvédelem tizenhárom éve (1969−1981) [Thirteen years of the Great Bustard conservation in Hungary]. – Környezet- és Természetvédelmi Évkönyv 7: 17–68. (in Hungarian)

Széll, A. 2005. A dévaványai Túzokvédelmi Mintaterület kialakítása és első eredményei [The establishment and first results of Great Bustard conservation sampling area in Dévaványa]. – A puszta 22: 173–208. (in Hungarian)

I1: http://www.kmnp.hu/index.php?pg=news_179_3083

I2: http://www.termeszetvedelem.hu/_user/downloads/agrar/61_2009_fvm_mellekletek.pdf