**Thesis of the Ph.D. dissertation**

# POPULATION INCREASE AND NEST SITE SELECTION OF THE HOODED CROW (*CORVUS CORNIX* L. 1758) IN URBAN ENVIRONMENT

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Debrecen
2015

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## BACKGROUND AND OBJECTIVES OF THE PH.D. THESIS

A spectacular result of the development of civilization is the appearance of the ever-expanding areas of urbanized environment. Ceaseless urbanization has been bringing forth larger and larger agglomerations of cities, interminable built-up areas. More than half of the total population of the world reside in cities, reaching even 80% in economically developed countries. With regard to the transformation of the environment several questions arise, such as what is going to happen to the wildlife, how would biological diversity be affected and how can different species adapt to the altered circumstances?

Certain species respondent to alterations deriving from urbanization have become ultimately excluded from the transformed environment, others, passing beyond the initially emerging unfavourable effects of environmental stress, have become veritable city-dwellers as a result of their adaptiveness. Some bird species are characterized by a rather significant breakthrough in the habitat, most of which previously lived in different natural habitats and which have become typical city birds, adjusting more and more to the special anthropomorphic habitats. Among the first, dealing with this issue in Hungary, Keve (1969, 1972, 1976/a, 1979) summarized this process in several studies, describing the change of habitats with regard to birds. The Eurasian collared dove, the blackbird and the house sparrow could be taken as example species for adjustment to urban environment. The above mentioned ones can be observed in urban areas throughout their lives, each day of the year, while other species only exploit periodically the beneficial conditions provided by cities (e.g. the fieldfare, the Bohemian waxwing, the common swift, the common starling, the black redstart). The rearrangement and adjustment of bird fauna is an ongoing process, diverging from the initial state, it comprises the settlement of further and further species even in densely built-up, inhabited areas. What can be the reason for this change?

The urban living-space can only function as a viable place for people if the concrete jungle is dispersed with green areas, parks, roadside tree rows, groups of bushes, patches of lakes, which can reduce the adverse effects of civilized environment, providing recreation and relaxation. Green areas reduce noise, absorb dust and other polluting agents, ponds can provide tranquillity for humans and the fauna, including birds as well, which settle down here. The advantages of the cities for the fauna comprise a great variety of food sources (crops and organic waste), shelter, nesting and breeding site, the absence of some specific predators is

also considered as a positive ecological condition. In the case of certain species these benefits highly overpass the unfavourable effects of the human environment, which can lead to an enhanced chance of survival and breeding at individuals from species preferring urban habitats than those staying at their original habitat.

In the recent decades an efficient colonization of the cities was achieved by the Hooded Crow, which has become part of our everyday life. This species, present in a number of cities in Europe from the 1960s, has completely adapted to the urban environment, taking the advantage of all its benefits. Besides the arrival and settlement of the Hooded Crow in several towns of this country, a considerable and spectacular expansion has been recorded in Debrecen in the past few years. The first appearance of the Hooded Crow in Debrecen was observed in 1959, in the northern boundaries of the city, in the Great Forest. Subsequently, it ”disappeared” for two decades, and only in 1979 can we read again about new nestings. The population with a stagnating number of individuals started to strengthen considerably in the early 2000s and after a while, became widespread all over the city.

The model of Evans et al. (2010) can entirely be applied to the case of Debrecen, in which the urbanization process of birds is divided into three phases: arrival, adjustment and spread. The arrival and settlement of the Hooded Crow in Debrecen can supposedly be associated with the game management of the region. The related data of the National Game Management Database from the mid 70s, show a decline. While the total number of hooded crows removed in the framework of population control amounted to 95 581 in 1973, in 2006 it was only 14 015. Due to the significant decrease, crow populations outside the towns were continuously strengthening, thus the way to the towns, to Debrecen, as well, were open for them. The process of adjustment could not have meant a real difficulty for them. Talking about corvidae, their opportunist behaviour – attached to a high level of intelligence – facilitated a quick adjustment to the conditions provided by the cities. These are primarily the range of food (e.g. rubbish dump, zoo), as well as, the nesting opportunities (parks, tree rows along streets/roads), which provide quite favourable ecological conditions. We have arrived to the last phase, and the present study aims at resolving the wide-ranging issues connected to it. The spectacular increase of the Hooded Crow populations provided a starting point for the research and determined its core issues.

### 1.1.Objectives

- Presenting how the spread phase of the Hooded Crow has taken place and is developing in Debrecen.
- Describing the nesting of the Hooded Crow in urban environment.
  - ➔ Specifying the location and types of habitats of the nest sites of these birds.
  - ➔ Examining preferences for nesting trees or nesting heights.
- The follow-up of fledglings.
  - ➔ Checking whether they remain in the city or leave it after fledging.
  - ➔ Measuring the home range of young birds, and how it changes over the years.

The significance of the research lays in the extension of the results concerning urban ecology and the follow-up of the recent colonization of a common, however, not sufficiently known bird species. The research also facilitates a detailed and ”real-time” study of the adjustment of hooded crows to the urban environment. It can contribute to a better understanding of the factors that made it possible for my target species to become such a successful urban bird species. Besides urban planning, the results of the study are also relevant in terms of nature conservation and game management, in the case of the latter one, it is particularly true for the urban game management.

## II. RESEARCH METHODS

### 2.1. Nest monitoring

Nest monitoring was carried out from 2006 and 2013. The size of the study area was 36 $km^2$, divided into 9 squares 4 $km^2$ each. The study area – following from its size – comprised all the main types of habitats in the city. Nest monitoring consisted of 3 stages: 1. monitoring in the period from late winter to early spring (the end of February - the beginning of March); 2. localization of active/inhabited nests (the end of March - the beginning of April); 3. visiting all the nests again for a standard survey of data (mid-April). As crows build new nests each year, the entire study area had to be searched again, street by street, each year.

The place of each nest found was marked on a map, including GPS coordinates, the species and the height of the nesting tree, as well as the height of the nest on the tree (TruPulse 200 laser rangefinder). In addition to this, the position of the nest on the tree and the habitat type were also recorded. For the description of the latter one, four nesting site categories were defined and delimited:

- *'single tree':* solitary – generally ample - tree individual, with no other trees surrounding it within a distance of 25-30 m, making allowance for bushes.
- *'tree row':* trees planted in a row along roads or streets.
- *'park':* a habitat consisting mainly of trees, with a canopy cover <70%, characterized by an infrastructure of buildings, lake, pavement, etc., as well.
- *'forest patch':* a smaller area fully covered by trees.

### 2.2. Colour ring marking

For the follow-up of youngs, colour ring marking was chosen. As this research programme was the first to use colour rings with this species in the country, an agreement with MME (BirdLife Hungary) and EURING (The European Union for Bird Ringing) was required. Following the approval of the Color-ring Birding Working Group of the latter organization, we could initiate the programme as the fifth one in Europe (http://www.cr-birding.be/cr-HoodedCrow.htm).

During the programme, nestlings were ringed in the nests. The approach to the nests was achieved with the help of a hired basket crane truck (LIAZ) with 20 m working height. Vehicle entry permits also had to be obtained, in addition, property protection and personal

safety priorities had to be taken into consideration. Adjusted to the weather conditions of each year, bird ringing was scheduled to the fledging period (the end of April - the beginning of May). Work started at 8.00 in the morning and finished most of the time at 14.00 in the afternoon. Standard aluminium rings were attached to every nestling's left leg. For colour ringing 1, 2 and finally, from 2011, the combination of three colours were used. Nine colours were applied (yellow, orange, red, lime, white, violet, light blue, dark blue and pink), strictly following the ringing scheme. Marked nestlings were placed back to the nest immediately after ringing. Two methods were elaborated concerning the collection of feedback data. One of them was checking a previously determined sample study areas, which we visited regularly (twice a week), while the other method was based on the feedback gained through the promotion of the programme. Paying attention to the possibility of the individuals' moving out of the city, we contacted all the game management units operating at the boundaries of the city, as well as, Hortobágy National Park.

Feedback from the colour-ringed birds was analysed using an estimated home range and the mean movement. On the basis of the documented coordinates, with the help of ArcGIS10.0 software, we created a shapefile containing points, in which we recorded attributes, such as the identification code of the birds, the year of sighting, and their age. The annual home range of the birds was described by minimum convex polygons based on the sightings of each individual from one year, we used Hawth's Tools extension (http://www.spatialecology.com/htools) of ArcGIS 9.3 software to elaborate it. Subsequently, in order to estimate the movements of the birds from one year to another, we proceeded from the distance between the centroids of home ranges, also calculated with the help of Hawth's Tools extension. In the process of analysing home ranges and movements, only those individuals were taken into account disposing of at least 5 sightings throughout the six-year period. We applied two-sample and paired t-tests in the analysis, adjusting the degrees of freedom in the case of the heterogeneity of variances.

### 2.3. Data analysis

We analysed nest density in relation to the entire city, as well as, reduced to the northern sample area (4km$^2$), where nesting is more intensive because of the more favourable features of the habitat.

We estimated the entire breeding area of the city by fitting a rectangle of minimum area over the most peripheral nests; in order to identify areas of identical nest density, we determined

kernel density (nine classes, kernel density tool: ArcGIS 10.0 software) on the basis of the same peripheral nests, positioned at the edges. Map-based data processing and illustration were achieved with the help of ArcGIS 10.0. We described nest height in the form of absolute height (field measurement in metre) and relative height. The latter one implies the comparative ratio of the nest height and the upmost point of the nesting tree. For instance, the relative height of a nest positioned at 8m on a 10m high tree is 0.8.

The variability of nest density and nest height was examined as a function of independent variables of habitat, tree species and year. Changes in the number and the density of nests over time (from one year to another) were analysed with simple linear and non-linear (polynomial) regression, in order to be able to detect a possible non-linear change. Because of the heterogeneity and non-regular distribution of variances in nest height data, tree height, absolute and relative nest height data related to habitat types and tree species were compared with the help of non-parametric Kurskal-Wallis tests. Mean nest height data from the scientific literature studying hooded crows' breeding in rural habitats were compared to our data gained from urban habitats using one-sample t-test. The analysis of tree species preference of hooded crows Ivlev-index (Ivlev, 1961) and independence test were used. In latter $\chi^2$ (chi-square) test required for comparing the frequency of different tree species used for nesting to the available tree species. If the crows do not show preference, we expect, according to null hypothesis, that tree species are used in the proportion correspondent to their availability. To describe the availability of different tree species in the northern and central part of Debrecen, we used data obtained from the tree inventory of the Mayor's Office. When the conditions of the chi-square test differed, i.e. the expected frequency was under 5 in the case of at least 20% of the possible combinations, we pooled neighbouring or rare categories. Statistical analysis was carried out with SPSS for Windows 17.0 (SPSS Inc., 2008) and PAST v. 2.17 software (Hammer et al., 2001). Texts, tables and figures contain mean values or values of standard deviation, unless determined otherwise.

## III. MAIN STATEMENTS OF THE THESIS

### 3.1. Continuously increasing nesting population in Debrecen

Throughout the 8-year period of the study we documented 331 active/inhabited nests in the study area. The number of the recorded nests showed an increase in the study area year by year. (**Figure 1**). The third degree polynomial relation between the years and the inhabited nests indicates that the process is continuous, in fact, it has accelerated in the last few years. Throughout the years, nest density calculated over the total study area increased from 1.2 nests/km$^2$ to 4.3 nest/km$^2$ (**Figure 2**). Concerning the northern part of the city (4km$^2$), an even sharper increase occurred. While during the first examined year, we recorded 2 nests/km$^2$, the last year's value was over 10 nest/km$^2$ (**Figure 3**). These results indicate a continuous growth in the hooded crow population in Debrecen, no sign of saturation can be detected.

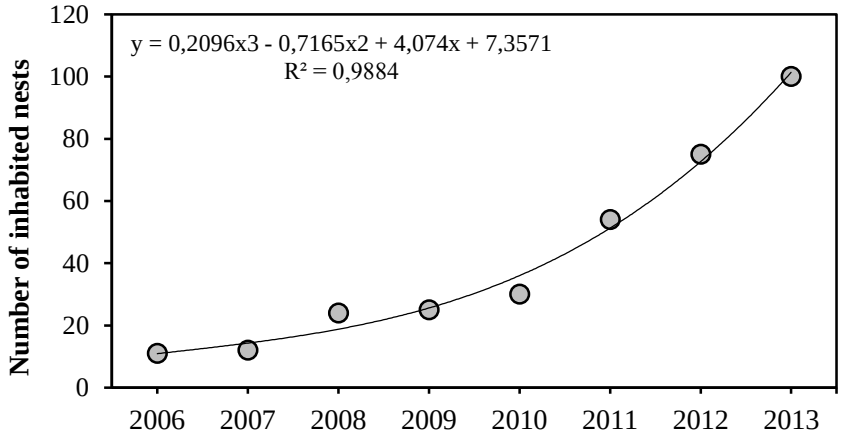



**Figure 1:** The number of localized nests (n=331) during the study period (2006-2013)

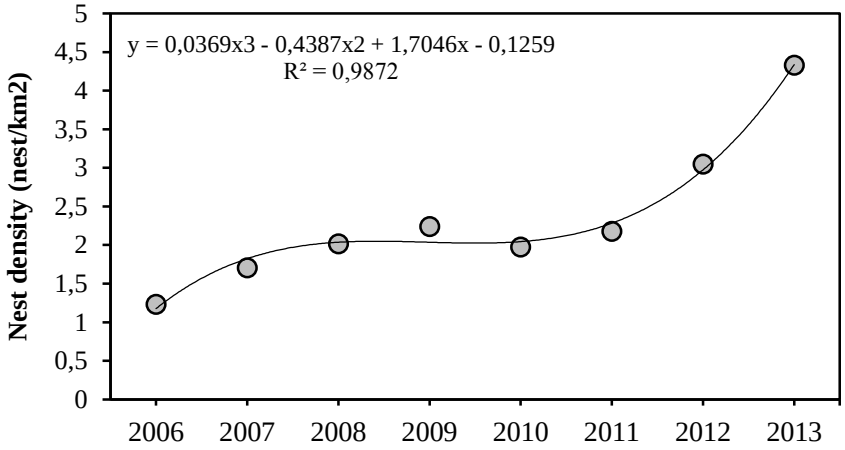



**Figure 2:** Changes in nest density during the study period (2006-2013) calculated over the total study area (36 km$^2$) (n=331)

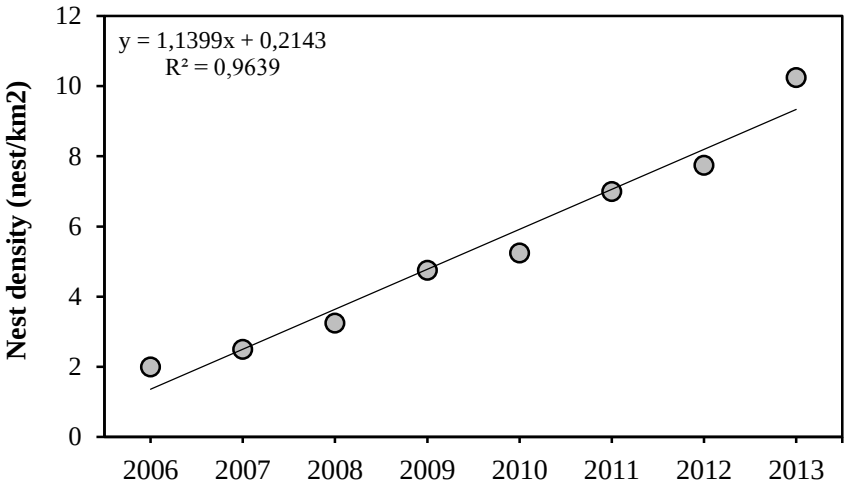



**Figure 3:** Changes in nest density during the study period (2206-2013) calculated over the northern part of the city (4 $km^2$) (n=171)

The adaptiveness of the Hooded Crow played an important role in the significant increase in the number of individuals in the city population; this ability facilitated the settlement, the survival and a gradual spread of the crows. The phenomenon was also promoted by the excellent nesting and food resources provided by the city. Our results show that the nest site selection of the pairs breeding in urban areas differs to a great extent from the pairs of rural areas in terms of habitats, tree species and nest height. This modified nest site selection implies an outstanding adaptiveness, which can be a clue to successful colonization. A number of undefined factors, however, could also contributed to the explosive population growth

### 3.2. Nest site selection of the Hooded Crow in urban habitats

Crows definitely avoided closed forests, which characterize mainly the northern part of the city. As opposed to this, single trees in parks, buildings and private gardens, tree rows along streets and roads, parks, as well as, loosely forested areas were rapidly populated by the crows during the years. They used, to an increasing extent, ’single tree’ (e.g. *Populus* spp.), ’tree row’ (e.g. *Celtis occidentalis*, *Sophora japonica*) and ’park’ (*Pinus* spp.) habitats, unlike ’forest patches’. The latter one seems obvious, as they avoid this habitat type, in the same way, in areas outside the city. With regard to the four habitats, we documented nests in similar proportions (**Table 1**), however, in the course of the years we found considerable differences. (**Figure 4**). The leading position of the ’tree row’ is not surprising as they breed in similar conditions outside the cities – on tree rows at the edges of cropland parcels (Cramp and

Perrins, 1994). The continuously growing number of nests in this habitat – particularly on Japanese pagoda trees and Common hackberry – resulted in a parallel decrease in nest height. It proves that the newly urbanized generations of crows exploited rapidly and efficiently the available new nesting possibilities.

**Table 1:** The distribution of the nest site selection of hooded crows during the study period (2006-2013), n=331.

| **Habitat** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **Total** | **Percentage (%)** |
|---|---|---|---|---|---|---|---|---|---|---|
| Single tree | 2 | 5 | 4 | 4 | 2 | 18 | 20 | 27 | 82 | 24,8 |
| Tree row | 2 | 1 | 8 | 7 | 12 | 16 | 19 | 28 | 93 | 28,1 |
| Park | 5 | 4 | 6 | 7 | 8 | 8 | 21 | 29 | 88 | 26,6 |
| Forest patch | 2 | 2 | 6 | 7 | 8 | 12 | 15 | 16 | 68 | 20,5 |
| **Total** | **11** | **12** | **24** | **25** | **30** | **54** | **75** | **100** | **331** | **100** |

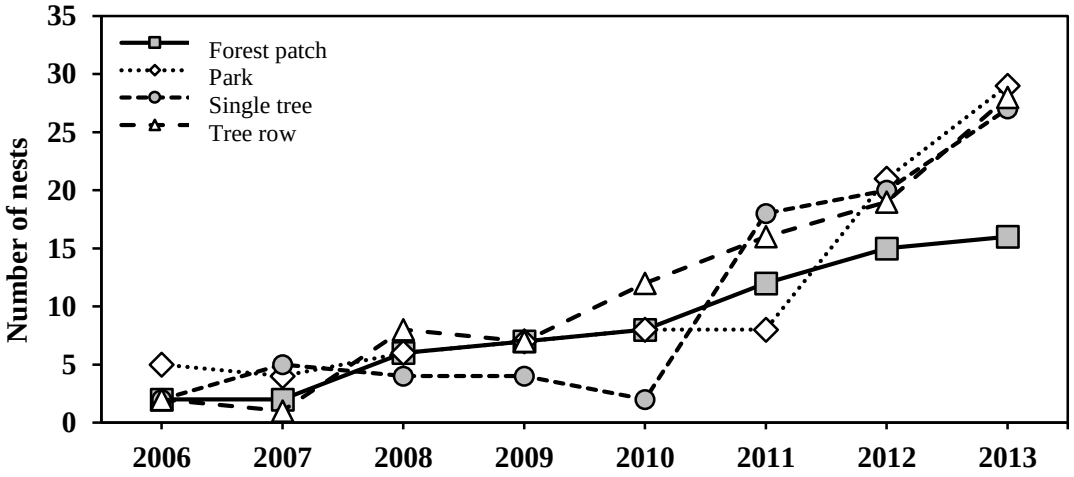



**Figure 4:** Changes in the number of nests during the years in different habitats

### 3.3. Preference of tree species and nest height

During the years of the study period, we found hooded crow nests in 20 tree species. (**Table 2**). Most of the nests were located in oaks (*Quercus spp.* n=81; total: 24.5%, n=331) and in conifers (*Pinus sylvestris* n=32, *P. nigra* n=19, *Picea abies* n=9; total: 18.1%), as it could be expected on the basis of the characteristics of the habitats and previous studies. Further, extensively used tree species are *Celtis occidentalis* (n=61; 18.5%) and *Sophora japonica* (n=35; 10.5%), which can be found in tree rows along streets and roads.

**Table 2:** The selection of nesting tree species of the Hooded Crow during the study period (2006-2013, n=331).

| **Tree species** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** | **2013** | **Total** |
|---|---|---|---|---|---|---|---|---|---|
| Pedunculate oak (*Quercus robur*) | 3 | 4 | 7 | 8 | 7 | 16 | 14 | 21 | **80** |
| Common hackberry (*Celtis occidentalis*) | 1 | 0 | 3 | 2 | 7 | 13 | 16 | 19 | **61** |
| Japanese pagoda tree (*Sophora japonica*) | 2 | 2 | 4 | 4 | 4 | 3 | 9 | 7 | **35** |
| Scots pine (*Pinus sylvestris*) | 3 | 3 | 3 | 4 | 6 | 2 | 6 | 5 | **32** |
| Poplar species (*Populus sp.*) | 0 | 0 | 1 | 0 | 0 | 6 | 9 | 12 | **28** |
| Black pine (*Pinus nigra*) | 1 | 0 | 3 | 2 | 1 | 3 | 5 | 4 | **19** |
| Hybrid plane (*Platanus hybrida*) | 0 | 2 | 0 | 0 | 1 | 2 | 4 | 10 | **19** |
| Black locust (*Robinia pseudoacacia*) | 0 | 1 | 1 | 3 | 1 | 2 | 3 | 4 | **15** |
| Silver maple (*Acer saccharinum*) | 0 | 0 | 0 | 1 | 1 | 1 | 4 | 6 | **13** |
| Turkestan Elm (*Ulmus pumila celer*) | 0 | 0 | 1 | 1 | 0 | 1 | 3 | 3 | **9** |
| Norway spruce (*Picea abies*) | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | **9** |
| Honey locust (*Gleditsia triachanthos*) | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **2** |
| Arborvitae species (*Thuja sp.*) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | **2** |
| Osage orange (*Maclura pomifera*) | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | **1** |
| Northern red oak (*Quercus rubra*) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **1** |
| Silver lime (*Tilia tomentosa*) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| Norway maple (*Acer platanoides*) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| Persian walnut (*Juglans regia*) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| Eastern black walnut (*Juglans nigra*) | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | **1** |
| Common alder (*Alnus glutinosa*) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | **1** |
| | **11** | **12** | **24** | **25** | **30** | **54** | **75** | **100** | **331** |

Besides these, poplar species (*Populus spp.*) played an important role (n=28; 8.5%) in the nesting of the crows. The remaining 12 tree species were used less frequently for nesting (<5%, n=331), in descending order of frequency they were the following: *Platanus hybrida, Robinia pseudoacacia, Acer saccharinum, Ulmus pumila celer, Gleditsia triacanthos, Thuja sp., Maclura pomifera, Tilia tomentosa, Acer platanoides, Juglans regia, Juglans nigra, Alnus glutinosa*. The use of tree species altered throughout the years in different ways. (**Figure 5**). We can find a significant difference ($\chi^2$=75,722, df=9, p<0,0001) between tree species used for nesting and the available ones. Crows preferred conifers (*Pinus spp.*) and oaks (*Quercus spp.*), they bred in the Common hackberry (*Celtis occidentalis*), the Hybrid plane (*Platanus hybrida*), the Japanese pagoda tree (*Sophora japonica*) and Turkestan Elm (*Ulmus pumila celer*) proportionately to the availability. They used maple species (*Acer* spp.) and the Black locust (*Robinia pseudoacacia*) to a lesser proportion in relation to their availability (**Table 3**)**.** We found the same results when the data were evaluated by Ivlev-index (**Table 4**). With regard to the Pedunculate oak, there is a strong correlation ($\chi^2$=7.567, df=1, p=0.006) between the presence of a nest and that of the European yellow mistletoe (*Loranthus europaeus*) (n=80 71.25%) (**Table 5**), whose shrubs provide a safer breeding site.

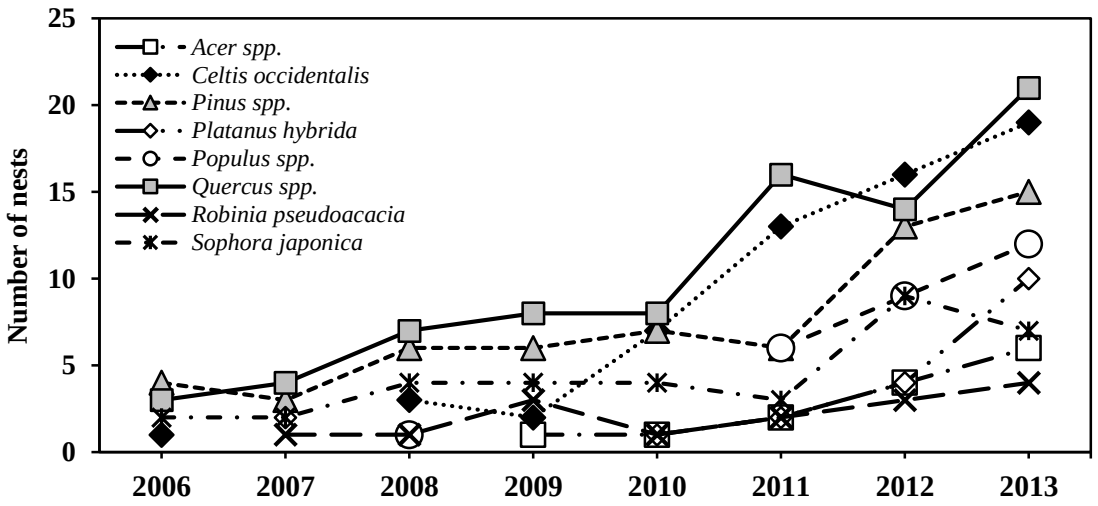



**Figure 5:** Changes in the number of tree species most frequently used for nesting during the years

**Table 3:** The number of hooded crow nests in different tree species/taxons (2006-2013, n = 182), and the expected number of tree species/taxons used, calculated according to null-hypothesis (no preference), based on the frequency of tree species/taxons within a 12,5 $km^2$ sample area.

| Tree species/taxon | Number of nests | | Used (%) | Availability (%) |
|---|---|---|---|---|
| | Observed | Excepted | | |
| *Acer* spp. | 9 | 54 | 4,95 | 29,93 |
| *Celtis occidentalis* | 52 | 48 | 28,57 | 26,17 |
| *Pinus* spp. | 17 | 1 | 9,34 | 0,34 |
| *Platanus hybrida* | 15 | 14 | 8,24 | 7,50 |
| *Populus* spp. | 18 | 2 | 9,89 | 1,33 |
| *Quercus robur* | 27 | 8 | 14,84 | 4,46 |
| *Robinia pseudoacacia* | 5 | 12 | 2,75 | 6,33 |
| *Sophora japonica* | 26 | 26 | 14,29 | 14,05 |
| *Ulmus pumila celer* | 8 | 6 | 4,40 | 3,33 |
| Other | 5 | 12 | 2,75 | 6,57 |

**Table 4:** Nesting tree preference of Hooded crow based on the Ivlev-index within a 12,5 $km^2$ sample area.

| Tree species/taxon | Number of nests | Number of tress | Ivlev-index |
|---|---|---|---|
| *Acer platanoides* | 1 | 3163 | -0.96 |
| *Acer saccharinum* | 8 | 459 | 0.07 |
| *Celtis occidentalis* | 52 | 3167 | 0.04 |
| *Gleditsia triacanthos* | 2 | 144 | -0.04 |
| *Juglans regia* | 1 | 194 | -0.49 |
| *Picea abies* | 3 | 11 | 0.89 |
| *Pinus nigra* | 13 | 8 | 0.98 |
| *Pinus sylvestris* | 1 | 22 | 0.50 |
| *Platanus hybrida* | 15 | 908 | 0.05 |
| *Populus* spp. | 18 | 161 | 0.76 |
| *Quercus robur* | 27 | 540 | 0.54 |
| *Robinia pseudoacacia* | 5 | 766 | -0.39 |
| *Sophora japonica* | 26 | 1700 | 0.01 |
| *Thuja* spp. | 2 | 457 | -0.55 |
| *Ulmus pumila* | 8 | 403 | 0.14 |
| Total | 182 | 12 103 | |

**Table 5:** Nesting preference of the Hooded Crow for yellow mistletoe during the studied years (2006-2013), n=331.

| | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Total | Percentage (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Q. robur*** | 3 | 4 | 7 | 8 | 7 | 16 | 14 | 21 | 80 | 100 |
| **mistletoe** | 1 | 4 | 5 | 7 | 5 | 10 | 10 | 15 | 57 | 71,25 |

The absolute mean height of nests was 16.7 ± 2.56 metre (between 12-23 m, n=331), while that of the trees holding the nests was 19.2 ± 2.89 metre (between 12-30 m, n=331). Taking all these into consideration, the relative nest height amounts to 87% ± 0.07%, which indicates that hooded crows living in the city tend to build their nests in the upper part of the trees. Regarding nesting height – both absolute and relative –, considerable dissimilarities are present among different tree species, which can be explained by the different characteristics of the tree species. (**Table 6**). The relative nest height was larger at gymnospermous trees (93.6 ± 5.41%, n = 62) than at angiospermous trees (85.9 ± 7.22%, n = 269; Mann-Whitney U = 3254, p < 0,0001). Our results show that the relative nest height varies significantly with different habitats (**Figure 6)**. It may suggest that the absolute nesting height is a more important factor in urban areas than the type of the nest site.

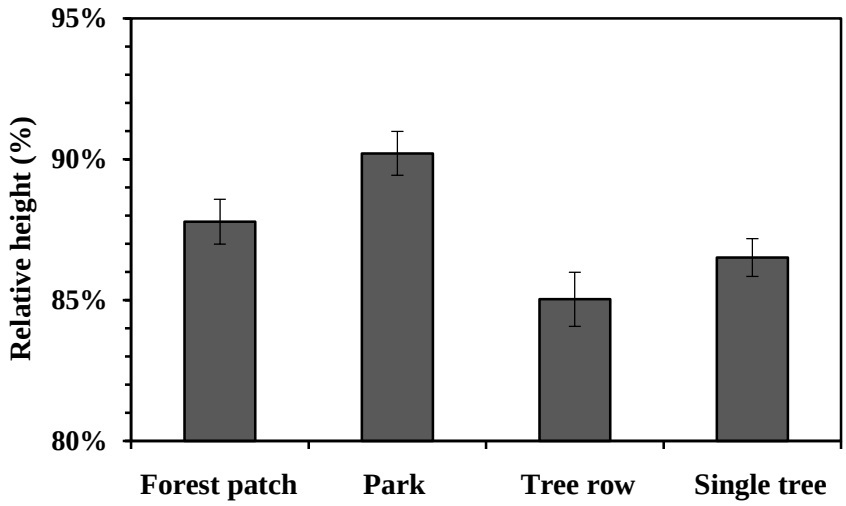



**Figure 6:** The mean (± S.E.) relative height of nests in different habitats (n=331)

The Hooded Crow preferred similar absolute nest height in each habitats (approx. 16.7 m) (**Figure 7**). In the case of shorter trees they compensated by building their nests in the treetops. From all these, we can conclude that crows can find their secure nesting heights at 16-17m in Debrecen. One of the most interesting results is that nests within Debrecen were built considerably higher – with a significant difference – in the trees than those outside the city (6.4 m; 2002). We can claim that in urban habitats, tree height is one of the most important factors in the nest site selection of the crows.

**Table 6:** Mean height and standard deviation of inhabited hooded crow nests and of the trees selected for nesting, as well as, their ratio (relative height of nests), n=331.

| Tree species/genus | Tree height | Nest height | Relative height | N |
|---|---|---|---|---|
| *Acer platanoides* | 15,0 ± 0,00 | 13,0 ± 0,00 | 87 ± 0,00 | 1 |
| *Acer saccharinum* | 21,5 ± 1,66 | 18,1 ± 2,47 | 84 ± 0,06 | 13 |
| *Alnus glutinosa* | 19,0 ± 0,00 | 17,0 ± 0,00 | 89 ± 0,00 | 1 |
| *Celtis occidentalis* | 18,2 ± 1,94 | 15,8 ± 1,89 | 87 ± 0,06 | 61 |
| *Gleditsia triachanthos* | 15,5 ± 3,54 | 12,0 ± 0,00 | 79 ± 0,18 | 2 |
| *Juglans nigra* | 21,0 ± 0,00 | 18,0 ± 0,00 | 86 ± 0,00 | 1 |
| *Juglans regia* | 17,0 ± 0,00 | 16,0 ± 0,00 | 94 ± 0,00 | 1 |
| *Maclura pomifera* | 15,0 ± 0,00 | 12,0 ± 0,00 | 80 ± 0,00 | 1 |
| *Picea abies* | 18,9 ± 2,42 | 16,9 ± 2,15 | 90 ± 0,53 | 9 |
| *Pinus nigra* | 16,0 ± 3,26 | 14,7 ± 2,67 | 93 ± 0,07 | 19 |
| *Pinus sylvestris* | 18,0 ± 2,18 | 17,2 ± 2,00 | 95 ± 0,04 | 32 |
| *Platanus hybrida* | 21,0 ± 3,89 | 18,1 ± 3,14 | 87 ± 0,07 | 19 |
| *Populus sp.* | 22,7 ± 2,67 | 18,1 ± 3,10 | 80 ± 0,09 | 28 |
| *Quercus robur* | 19,5 ± 2,47 | 17,2 ± 2,47 | 88 ± 0,07 | 80 |
| *Quercus rubra* | 19,0 ± 0,00 | 15,00 ± 0,00 | 79 ± 0,00 | 1 |
| *Robinia pseudoacacia* | 19,7 ± 1,62 | 16,9 ± 2,19 | 86 ± 0,06 | 15 |
| *Sophora japonica* | 19,0 ± 2,48 | 16,2 ± 2,30 | 85 ± 0,06 | 35 |
| *Thuja sp.* | 18,0 ± 0,00 | 17,0 ± 0,00 | 94 ± 0,00 | 2 |
| *Tilia tomentosa* | 14,0 ± 0,00 | 12,0 ± 0,00 | 86 ± 0,00 | 1 |
| *Ulmus pumila celer* | 18,2 ± 1,20 | 15,8 ± 1,48 | 87 ± 0,04 | 9 |
| **Mean/st. deviation** | **19,2 ± 2,89** | **16,7 ± 2,56** | **87 ± 0,07** | **331** |
| **Kruskal-Wallis H (p)** | **82,42 (<0,0001)** | **38,27 (<0,0004)** | **79,88 (<0,0001)** | |

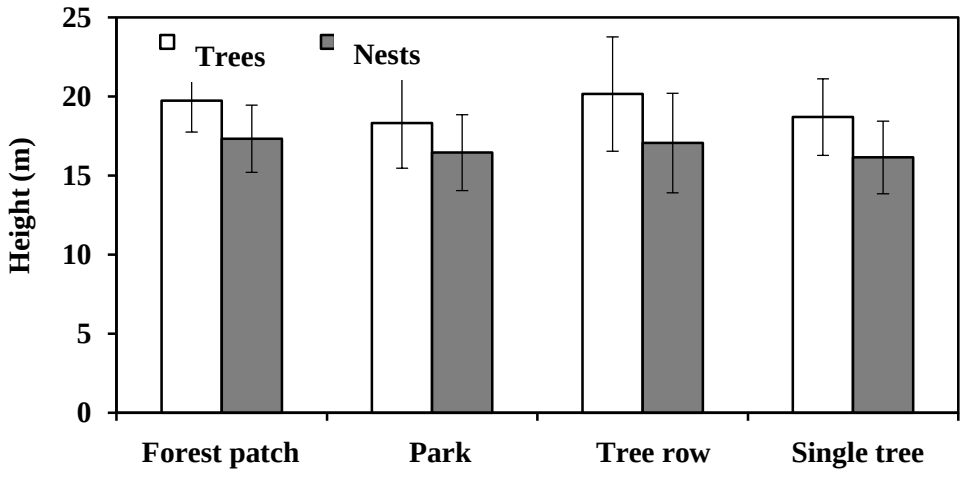



**Figure 7:** Mean height (± S.D.) of trees used for nesting and that of the nests in different habitats (n=331)

### 3.4. Banded crows in the city

During our colour ring programme, we marked 138 nestlings from 48 nests individually with colour rings (**Table 7)**.

**Table 7:** Results of the colour ringing from seven sessions (2007-2013)

| Year | Date of ringing | Visited nests (pcs) | Deserted nests (pcs) | Nests with eggs (pcs) | Nests with nestlings (pcs) | Ringed nestlings (pcs) |
|---|---|---|---|---|---|---|
| 2007 | May 7 | 4 | 2 | 0 | 2 | 8 |
| 2008 | April 30 | 8 | 0 | 3 | 5 | 13 |
| 2009 | April 30 | 6 | 0 | (2)* | 6 | 17 |
| 2010 | May 10 | 6 | 0 | 1 | 5 | 16 |
| 2011 | May 9 and 10 | 14 | 5 | 0 | 9 | 33 |
| 2012 | May 3 and 4 | 16 | 1 | 2 | 13 | 25 |
| 2013 | May 15 | 10 | 2 | 0 | 8 | 26 |
| **Total:** | | **64** | **10** | **8** | **48** | **138** |

(*): together with nestlings

During the years, we gained feedback from 48 individuals (34.8%), which means 273 data records. Only one (n=19), two (n=7), or three (n=6) sightings were received of most of the birds, however, there were individuals that produced ten, twenty or even thirty sightings (**Figure 8**).

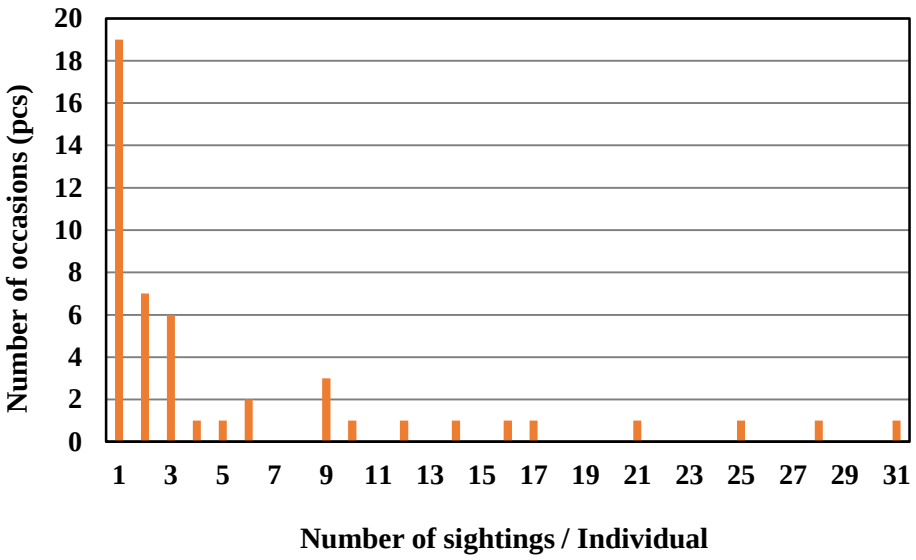



**Figure 8:** Summary diagram on the sightings of colour-ringed crows (n=48)

The mean home range size of the fifteen birds studied more thoroughly was 14.86 ± 25.16 hectare. In the case of three birds out of six (**Figure 9,** identification codes: 19, 25, 28), home range increased significantly in the year following the fledging, while the other three (identification codes: 20, 26, 38) showed no considerable change. On the whole, the estimated mean home range of individuals in the year of fledging was smaller (6.84 ± 4.76 ha) than the estimated mean home range in the first year after fledging (29.38 ± 38.30 ha), which, however, did not differ significantly because of the higher values of standard deviation (paired t=1.550, n=6, p=0.182). The home range of most of the birds increased considerably in the first year after fledging compared to the year of fledging, and remained more or less stable in the years subsequent to the second one (**Figure 10**). It can be explained by the fact that in the first year, the young and the parents only move within a 'limited' territory around the nest. In the first year after fledging, it wanders, and it is likely that from the second one, it occupies a territory, or stays in a preferred area.

With regard to the centroids of the home ranges, the mean movement calculated over the years was 409.8 ± 316.22 m volt (n=11). The mean movement of the marked birds between the fledging year and the following year, was 381.2 ± 299.26 m (n=6), while in the subsequent years, it was 444.0 ± 367.89 m (n=5). This difference, however, as a result of the considerable standard deviation, was not significant (t=0.313, p=0.761).

Throughout the years of the study, no feedback was received on marked hooded crows from either the neighbouring game management units or Hortobágy National Park. According to the collected data, crows fledging in urban habitats are unlikely to leave Debrecen, youngs stay in close proximity to the fledging site.

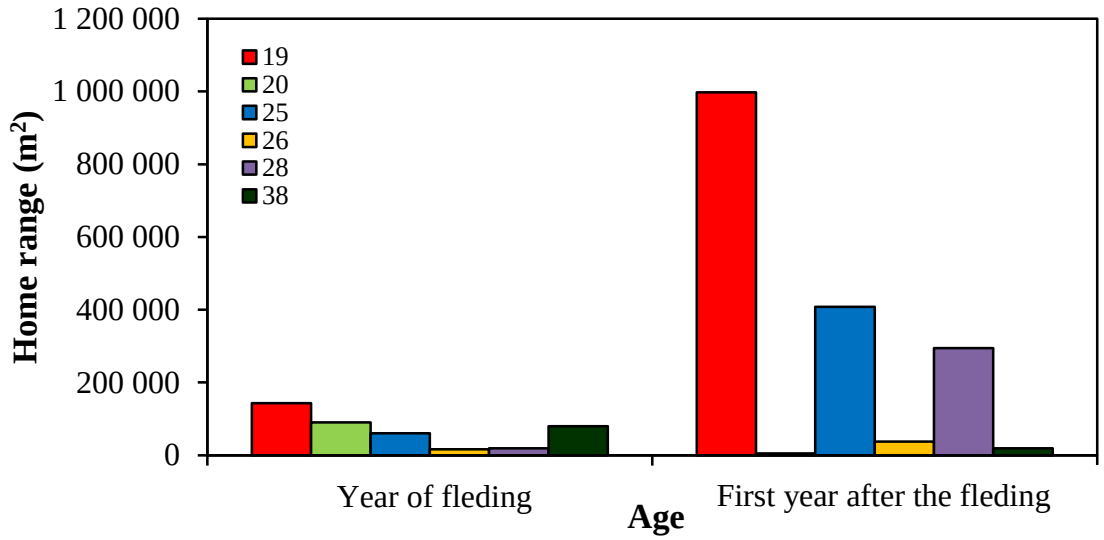



**Figure 9:** Home range of minimum three times observed fledglings (n=6) in the year of fleding and in the first year after fleding. At the upper left corner you can see the identification number of individuals.

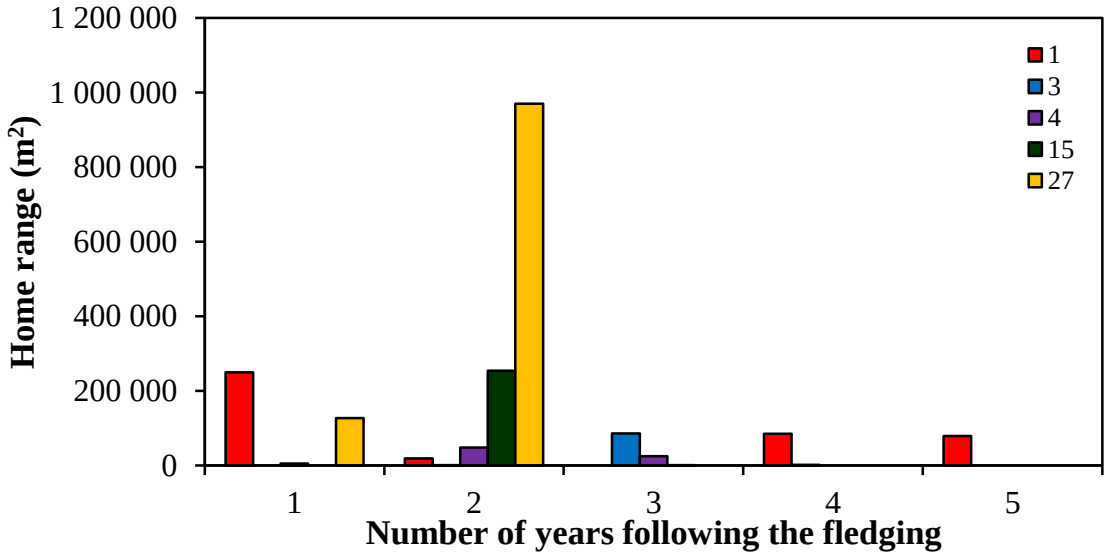



**Figure 10:** Home range of fledglings (n=5) whom did not observed in the year of fleding but the following years are. At the upper right corner you can see the identification number of individuals.

## IV. NEW STATEMENTS OF THE THESIS

**1.** The settlement of the Hooded Crow in Debrecen started in the northern part of the city, where its population is still dominant. Throughout the years, both in the northern area (4 $km^2$) and in the entire sample area (36 $km^2$), a continuous increase was documented considering nesting population and nest density. On the basis of this growing tendency and of previous studies from abroad, a further population growth can be expected. The present study provides a detailed documentation of the population growth and the increase in spatial expansion.

**2.** For nesting sites, urban crows preferred conifers (*Pinus spp.*), poplar species (*Populus spp.*) and oak species (*Quercus spp.*). They bred, in a significant number, on Common hackberry (*Celtis occidentalis*), Hybrid plane (*Platanus hybrida*), Japanese pagoda tree (*Sophora japonica*) and Turkestan Elm (*Ulmus pumila celer*) proportionately to the availability. Compared to the availability, they used maple species (*Acer* spp.) and Black locust (*Robinia pseudoacacia*) to a lesser extent.

**3.** The nesting of the Hooded Crow in Debrecen is characterized by building nests considerably higher (16.7 m) than individuals from populations living outside the city. It was proved that in urban environment, the most important factor of nest site selection is tree height.

**4.** The Hooded Crows of Debrecen preferred similar nest height in each habitat, compensating it by building the nest in the treetop part in the case of shorter trees. In Pedunculate oaks, they built the nest, with considerable frequency, close to the stem of the yellow mistletoe (*Loranthus europaeus*), while in conifers, with a more closed foliage, nests were positioned relatively higher. These observations indicate that crows try to conceal their nests or make the approach more difficult.

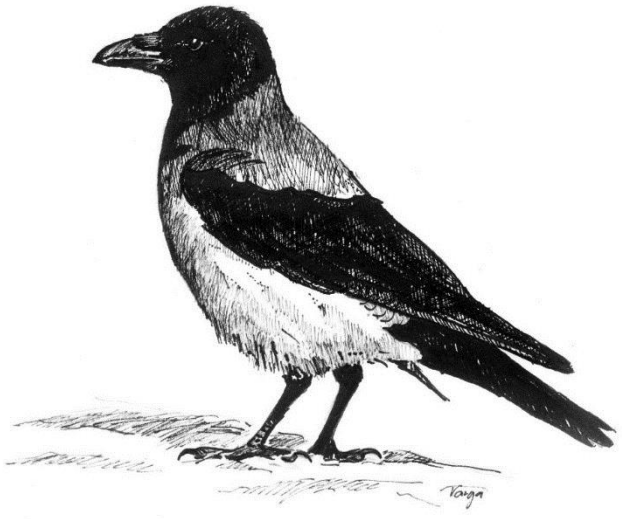
**5.** The crows completely avoided closed forests, while the four urban habitat were used almost the same proportion. The rate of use of certain habitat types, eg. ’single tree’ was grown significantly in the last three years.

**6.** It was proved that the settlement and the continuous population growth of the Hooded Crow in Debrecen were facilitated by their flexibility in habitat and nest site selection. Choosing previously avoided parts of the city, habitats exposed to human disturbance, less used tree species provided such advantages that promoted the successful colonization of the new, urban environment.

## V. PRACTICAL APPLICABILITY OF THE RESULTS

Corvidae have populated almost all the territories of the earth, several species have also become urbanized. They are supposed to cause wide-ranging problems for humans both in natural and urban habitats. Focusing on their urban activities, their noisy ”cawing”, and the more and more frequent aggressive behaviour can be emphasized. Further questions arise in connection with their impact on urban avifauna (predation), their possible role as vectors of pathogens and other special cases (mechanical damages to buildings).

It can be claimed that researching and studying the urban fauna is essential from the point of view of finding solutions for the recurrent issue of different human-animal interactions. Taking all these into consideration, the present study can provide applicable reference for urban planning, nature conservation and game management (urban game management) both nationally and internationally.



# VI. LIST OF PUBLICATIONS RELATED TO THE DISSERTATION

UNIVERSITY OF DEBRECEN
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Registry number: DEENK/55/2015.PL
Subject: Ph.D. List of Publications

Candidate: László Kövér
Neptun ID: QPY1L0
Doctoral School: Doctoral School of Animal Husbandry
MTMT ID: 10038991

**List of publications related to the dissertation**

Hungarian book chapter(s) (1)

1. **Kövér L.**: Nemzetközi minősítő szervezetek a természetvédelemben, különös tekintettel a Greenpeace-re, a WWF-re és az IUCN-re.
   In: A nemzetközi minősítő, értékelő és véleményalkotó szervezetek hátteréről és nemzeti szuverenitásra gyakorolt hatásáról. Szerk.: Babos Tibor, Czene Gréta, Morvai Tünde, PI-NET, Budapest, 142-160, 2013. ISBN: 9789630872898

Hungarian scientific article(s) in Hungarian journal(s) (7)

2. **Kövér L.**: Színes gyűrűs dolmányos varjak (Corvus corone cornix L.) Debrecenben.
   *Calandrella. 15*, 176-183, 2012. ISSN: 0238-2598.



3. Juhász L., **Kövér L.**, Gyüre P.: A debrec[illegible] varjú (Corvus cornix L. 1758) populáció fészkelésbiológiája.
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   *Agrártud. Közl. 48*, 43-48, 2012. ISSN: 1587-1282.

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Tel.: +36 52 410 443 Fax: +36 52 512 900/63847 E-mail: publikaciok@lib.unideb.hu, ¤ Web: www.lib.unideb.hu

6. Juhász L., **Kövér L.**: A dolmányos varjú (Corvus cornix) expanziója Debrecenben.
*Debr. Szle. 3*, 312-321, 2011. ISSN: 1218-022X.

7. Juhász L., **Kövér L.**, Juhász P., Vári E.: A dolmányos varjú (Corvus cornix L.) urbanizálódása Debrecenben.
*Calandrella. 13*, 98-105, 2010. ISSN: 0238-2598.

8. **Kövér L.**, Juhász L.: A dolmányos varjú (Corvus cornix L.) debreceni terjeszkedése.
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Foreign language scientific article(s) in Hungarian journal(s) (1)

9. **Kövér, L.**, Juhász, L., Gyüre, P.: Nest-site preference of Hooded Crow (Corvus cornix L.) in Debrecen, Hungary.
*J. Agric. Sci. 44*, 13-17, 2011. ISSN: 1588-8363.

Foreign language scientific article(s) in international journal(s) (2)

10. **Kövér, L.**, Gyüre, P., Balogh, P., Huettmann, F., Lengyel, S., Juhász, L.: Recent colonization and nest site selection of the Hooded Crow (Corvus corone cornix L.) in an urban environment.
*Landsc. Urban Plan. 133*, 78-86, 2015. ISSN: 0169-2046.
DOI: http://dx.doi.org/10.1016/j.landurbplan.2014.09.008
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11. Baltensperger, A.P., Mullet, T.C., Schmid, M.S., Humphries, G.R.W., **Kövér, L.**, Huettmann, F.: Seasonal observations and machine-learning-based spatial model predictions for the common raven (Corvus corax) in the urban, sub-arctic environment of Fairbanks, Alaska.
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DOI: http://dx.doi.org/10.1007/s00300-013-1376-7
IF:2.071

Hungarian conference proceeding(s) (8)

12. **Kövér L.**, Tóth N., Juhász L.: Városi természetvédelem csapdákkal: Lehetőségek a dolmányos varjú ellen.
In: IX. Magyar Természetvédelmi Biológiai Konferencia : "Tudományoktól a döntéshozatalig" : Absztrakt-kötet. Szerk.: Lengyel Szabolcs, Magyar Biológiai Társaság : MTA Ökológiai Kutatóközpont, Budapest, 77-78, 2014.

13. **Kövér L.**, Tóth N., Juhász L.: Csapdákkal a városi varjak ellen.
In: Innováció és Kreativitás a Tudományban : Konferencia CD kiadvány [elektronikus dokumentum]. [s.n], [s.l.], 121-128, 2013.

14. **Kövér L.**: A dolmányos varjú (Corvus cornix L.) színes gyűrűs jelölése Debrecenben.
In: III. SzaKKKör Konferencia [elektronikus dokumentum] : Szakkollégiumok Konferenciája a Környezet- és Természetvédelemért : ... előadásainak összefoglalói. Szerk.: szerk. Takács Márton, SZIE Környezetvédelmi (Zöld) Szakkollégium, [Gödöllő], [1], 2012. ISBN: 9789632693217

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In: Határokon átívelő tudományos és kulturális kapcsolatok - konferenciák : a Tormay Béla Szakkollégium kutatási eredményei. Debrenei Egyetem, Tormay Béla Szakkollégium, Debrecen, 139-147, 2012. ISBN: 9789630842105

16. **Kövér L.**, Juhász L., Gyüre P.: A dolmányos varjú (Corvus cornix L.) költése városi környezetben.
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17. **Kövér L.**, Juhász L., Gyüre P.: A debreceni dolmányos varjú (Corvus cornix L.) populáció fészkelésbiológiája.
In: VII. Magyar Természetvédelmi Biológiai Konferencia : "Többfrontos természetvédelem : önkéntesek, hivatásos természetvédők és kutatók összefogása természeti értékeink megőrzéséért" : Debreceni Egyetem, 2011. november 3-6. : program és absztrakt-kötet. Szerk.: Lengyel Szabolcs, Varga Katalin, Kosztyi Beatrix, Magyar Biológiai Társaság, Budapest, 128-129, 2011.

18. Takács A., Juhász L., **Kövér L.**: Adatok a Debrecen városában élő dolmányos varjú (Corvus cornix) parazita faunájához.
In: Természetvédelmi állatorvoslás : terepi programok és az állatkertek szerepe : a Magyar Vad- és Állatkerti Állatorvosok Társasága valamint a Fővárosi Állat- és Növénykert közös konferenciája. Szerk.: Liptovszky Mátyás, Sós Endre, Molnár Viktor, M. Vad- és Állatkerti Állatorvosok Társasága : Bp-i Állatkert, Budapest, 79, [2011]. ISBN: 9789638811240

19. **Kövér L.**, Juhász L., Gyüre P.: A dolmányos varjú (Corvus cornix L.) élőhelyváltozása Debrecenben.
In: IV. Kárpát-medencei Környezettudományi Konferencia. Szerk.: Orosz Zoltán, Szabó Valéria, Molnár Géza, Fazekas István, REXPO Kft., Debrecen, 197-204, 2008. ISBN: 9789630646260

Foreign language conference proceeding(s) (9)

20. **Kövér, L.**: Crows in European cities: An urban ecology research.
In: Baku World Forum of Young Scientists : Collection of Abstracts. [s.n.], [S.l.], 195, 2014.

21. **Kövér, L.**: Crows in the city - an urban ecology issue the colour ring program of Hooded Crow (Corvus cornix L.) in urban environment.
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23. Baltensperger, A.P., Schmid, M., Mullett, T., **Kövér, L.**, Huettmann, F.: Predicted spatial distribution models for the common raven (Corvus corax) in a patchy urban environment.
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25. **Kövér, L.**, Juhász, L., Gyüre, P.: The nesting of hooded crow (Corvus cornix) in Debrecen (Hungary).
In: Reproduction in wild vertebrates : proceedings from a symposium in Uppsala, Sweden february 10, 2011. Ed.: Björn Brunström, Jonas Malmsten, Bodil Ström Holst, Galia Zamaratskaia, Centre for Reproductive Biology in Uppsala, Uppsala, 23, 2011. ISBN: 9789157690289

26. **Kövér, L.**, Juhász, L., Gyüre, P.: Colour ringing of the Hooded Crow (Corvus cornix L.) in urban enviroment.
In: XXXth IUGB Congress (International Union of Game Biologists) and Perdix XIII. publ. by Manel Puigcerver ... et al.., IUGB, Barcelona, 318, 2011.

27. **Kövér, L.**, Juhász, L., Gyüre, P.: The expansion of the Hooded Crow (Corvus cornix L.) in Debrecen, Hungary.
In: 63th Students' International Scientific Conference : Book of Resume. [s.n.], [Moscow], [3], 2010.

28. Juhász, L., **Kövér, L.**, Gyüre, P.: The urbanization of the Hooded Crow (Corvus cornix L.) in Debrecen (Hungary).
In: Book of abstracts of 2nd European Congress of Conservation Biology. Czech University of Life Sciences, Prága, 227, 2009. ISBN: 9788021319615

Informational/educational article(s) (7)

29. **Kövér L.**, Tóth N., Juhász L.: Létrás csapdával a dolmányos varjakkal szemben - akár lakott környezetben is: Apróvad-gazdálkodás a mindennapokban.
*Nimród. 10* (5), 20-21, 2014. ISSN: 0549-494X.

30. **Kövér L.**, Duenas S., Korobytsin D., Korobytsina M., Huettmann F.: Küzdelem, változó sikerrel: Összefogás a tengeri teknősökért.
*Természetbúvár. 69* (1), 30-33, 2014. ISSN: 0866-1510.

31. **Kövér L.**: Dolmányosvarjú-kutatás.
*Egyetemi Élet. 52* (9), 12, 2014. ISSN: 0230-7731.

32. Juhász L., **Kövér L.**: Dolmányos városlakók.
*Term. Vil. 144* (9), 401-403, 2013. ISSN: 0040-3717.

33. **Kövér L.**: Bemutató madárgyűrűzés az Egyetemen.
*Egyetemi Élet. 51* (8), 12, 2013. ISSN: 0230-7731.

34. **Kövér L.**: Egyetemi madáretető.
*Egyetemi Élet. 51* (7), 31, 2013. ISSN: 0230-7731.

35. Juhász L., **Kövér L.**: A dolmányos varjú: Az agresszív városhódító.
*Nimród. 98* (1), 7-9, 2010. ISSN: 0549-494X.

**Total IF of journals (all publications): 4,677**
**Total IF of journals (publications related to the dissertation): 4,677**

The Candidate's publication data submitted to the iDEa Tudóstér have been validated by DEENK on the basis of Web of Science, Scopus and Journal Citation Report (Impact Factor) databases.

05 March, 2015

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