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Spatial patterns of seasonal distribution of Corvidae (the case of urban habitats)

A.V. Matsyura[1], A.A. Zimaroyeva[2], K. Jankowski[3]

[1]*Altai State University, Barnaul, Russia*
[2]*Zhytomyr National Agroecological University, Zhytomyr, Ukraine*
[3]*Siedlce University of Natural Sciences and Humanities, Siedlce, Poland*

Corvids in Zhytomyr city reach maximum density in the winter period. Rooks and Eurasian Jackdaws were the most abundant species in winter, usually feeding in multispecies flocks and forming collective roosts. Suburban green areas (buffer zones) were characterized by a considerably high diversity of Corvidae species: this habitat was occupied by all six species. We also registered the highest density of Eurasian Jays and Hooded Crows in this habitat. The green areas in the city center were also characterized by significant corvid density, especially during the breeding season. The maximum breeding density of Rooks was in these habitats, which held 6 of 12 identified urban colonies in Zhytomyr. We found that the European Magpies, Eurasian Jays, and Hooded Crows also had high breeding success here. Eurasian Jackdaws occurred here only in autumn and winter, when they fed together with Rooks on lawns, gardens, and parks. With stable snow cover the Rook density in habitats of the green areas decreased due to the depletion of food resources. The individual buildings zone of the city were characterized by the lowest density of all corvid species, except for European Magpies and Eurasian Jays. The number of common species (Rooks, Eurasian Jackdaws, and Hooded Crows) was low because of shortage of food resources, lack of sites for large roosting flocks and shortage of suitable nesting sites. However, Eurasian Magpies reached one of their highest densities in this habitat (12.8 birds/km^2). This species was registered in habitats around private buildings all the year round, successfully nesting in the yards of private houses and on trees in the streets. Its breeding density was 11.2 birds/km^2. During three years of research (2009–2012) the density of all corvids except for European Magpie, practically did not change, although we determined a slight positive trend for all the species. The strong increase in the number of Eurasian Jackdaws could be explained by the increasing density of wintering populations or due to the increasing number of migrants from more northern regions.

Keywords: habitat pattern; spatial distribution; abundance; urban-rural gradient; Ukraine

Пространственные особенности сезонного распределения врановых (анализ городских биотопов)

О.В. Мацюра[1], А.А. Зимароєва[2], К. Янковський[3]

[1]*Алтайский государственный университет, Барнаул, Россия*
[2]*Житомирский национальный агротехнологический университет, Житомир, Украина*
[3]*Естественно-гуманитарный университет в Седльце, Седльце, Польша*

В течение 2009–2012 гг. проведено исследование пространственного распределения врановых птиц в Житомирской области относительно градиента антропогенной нагрузки и сезонов года. Росту численности и дальнейшей урбанизации серой вороны, по нашему мнению, способствует большое количество кормов антропогенного происхождения, что позволяет птицам пережить суровые погодные условия. Интенсивный рост численности серой вороны сдерживает конкуренция со стороны грача. За период исследований заметно изменилась плотность галки в городских биотопах, что свидетельствует о росте численности городских

Алтайский государственный университет, пр. Ленина, 61, Барнаул, 656049, Россия
Altai State University, Lenin Ave., 61, Barnaul, 656049, Russia

Житомирский национальный агротехнологический университет, ул. Старый бульвар, 7, Житомир, 10008, Украина
Zhytomyr National Argoecological University, Stary Boulevard, 7, Zhytomyr, 10008, Ukraine

Естественно-гуманитарный университет в Седльце, ул. Конарского, 2, Седльце, 08-110, Польша
Siedlce University of Natural Sciences and Humanities, ul. Konarskiego, 2, Siedlce, 08-110, Poland
Tel.: +38-098-799-55-13. E-mail: anastasia_zima@yandex.ru, amatsyura@gmail.com, kazjankowski@gmail.com

популяций и доказывает, что в условиях Житомирской области галка является типичным синурбанистом. Сойка активно заселяет все типы населенных пунктов области, а также продолжается ее внедрение в наиболее преобразованные человеком ландшафты (крупные города), где численность вида из года в год растет. Это свидетельствует об активной синантропизации вида. Средняя плотность ворона за три года наших исследований существенно не изменилась, хотя и наблюдалось ее незначительное повышение.

Ключевые слова: биотоп; пространственное распределение; численность; антропогенная нагрузка; градиент урбанизации; Украина

Introduction

Corvids have a significant impact in urban areas and human transformed landscapes, especially in the places of their permanent concentrations (Marzluff and Rodewald, 2008; Catterall, 2009; Jokimäki et al., 2009). Large concentrations of birds could lead to changes in physical and chemical soil properties, microbiological processes, air composition, the composition and structure of plant communities (Fernandez-Juricic and Jokimäki, 2001; Bonier et al., 2007; Blair and Johnson, 2008; Evans et al., 2010; Luck and Smallbone, 2010). High densities of populations of Corvidae in urban environments facilitate extensive circulation of arboviruses, including influenza viruses, which they are able to spread over wide areas (Hundson, 1998; Ditchkoff et al., 2006; Anderies et al., 2007).

Many corvids feed on waste, fruits and young shoots of crops, so they affect the sanitary conditions of human settlements and agricultural fields (Ruszczyk et al., 1987; Chace and Walsh, 2006; Evans et al., 2009; Conole and Kirkpatrick, 2011). They also cause definite inconvenience within urban areas due to the noise from colonies and their droppings, which contaminate the soil and ruin architectural objects (Ruszczyk et al., 1987; Jerzak, 1995; Clergeau et al., 1998; Mac Nally, 2000).

The rapid human transformation of Corvidae habitats deeply affects all aspects of their lives, causing the formation of natural eco-ethological adaptations to changing environmental conditions (Marzluff et al., 2001; Jokimäki et al., 2009; Luck and Smallbone, 2010; Møller et al., 2012; Ramalho and Hobbs, 2012; Laband et al., 2013). Therefore, by the study of corvid ecology in urban areas and natural landscapes we can determine the environmental conditions of bird invasions of human settlement areas and the appearance of new ecological features (Ramalho and Hobbs, 2012; Laband et al., 2013). This could also help to manage the numbers and behavior of birds in areas of human settlement.

In Ukraine the study of the avifauna of urban environments is considered to be a relatively young branch of science, which has not yet attracted sufficient attention (Matsyura et al., 2015a). We discovered that interest in urban birds and their adaptive characteristics, geographical distribution and habitat preference has grown rapidly over the past ten-fifteen years (Savard et al., 2000; Zeller and Schuffernecker, 2004; Grimm et al., 2008; Ciach, 2012). It is obvious that information about the composition and number of birds of Zhytomyr is extremely limited, obsolete and requires detailed study (Matsyura et al., 2015b).

Materials and methods

We have identified some 5 types of urban bird habitat in Zhytomyr and the suburban "green zone" (mixed forests, forest parks, and ponds): old building zones (2–5 floors), multi-storey building zones (9–14 floors), individual buildings zones, habitats with artificial green spaces (parks, squares, boulevards), industrial landscapes. The allocation of these habitats was based on the ratio of different types of building, their location in the city, degree of habitat gardening and the levels of human impacts on habitat.

The gradient of urbanization increases toward suburban green areas at local level (in the city): forests, riverine habitats, fields – buffer zones, which are closely associated with the city's economic activity and the flow of tourists, individual buildings, city parks, squares, boulevards, gardens, industrial buildings (industrial landscape), typical multi-storey buildings (Matsyura and Zimaroeva, 2016).

We highlighted two specific habitats that are quite important for corvid survival, especially in winter – the meat processing plant and the landfill waste. The Zhytomyr meat processing plant is located in the industrial area and covers about 17 hectares. Maples are the dominant tree in this habitat.

Zhytomyr landfill (solid waste) is located on the southern outskirts of the city. It has an area of about 21.6 hectares and has accumulated about 15 million m^3 of waste with an annual increase of 0.4–0.5 million m^3. The dominant tree species here are planted poplars and pines.

We selected six bird species for our study: Rook (*Corvus frugilegus* L.), Eurasian Jackdaw (*C. monedula* L.), Hooded Crow (*C. cornix* L.), Common Raven (*C. corax* L.), European Magpie (*Pica pica* L.), and Eurasian Jay (*Garrulus glandarius* L.).

The study is based on the results of field studies conducted from September 2009 to August 2012 in the city of Zhytomyr.

We performed counts using the transect method with variable strips (because in different routes there were different distances between the buildings), i.e. a series of fixed fields, adjacent to each other (Matsyura, 2015a). Area correction (density of birds – the number of individuals per km^2) was performed using the formula:

$$N = \frac{n_1}{S},$$

where N – the number of birds per km^2, n_1 – number of recorded birds, S – site area.

Width of transect was averaged, within the old houses zone (3–5 storeys) it was 60 m; within the individual buildings zone – 100 m; multi-storey buildings zone (9–14-stores) – 80 m; in the industrial zone – 200 m; within parks, squares, and boulevards – 300 m.

In city parks and forest belts we counted the birds by interval survey with unlimited transect. Recalculation of the obtained ratio for the area (number of individuals per km^2) was carried out by the average of detected bird ranges (Ruszczyk et al., 1987; Tratalos et al., 2007). Recalculating was made by means of standard formula:

$$N = \frac{n_1 \times 60 + n_2 \times 100 + n_3 \times 80 + n_4}{L},$$

where n_1–n_4 – the number of individuals registered in detection strips of 0–25, 25–100, 100–300 and 300–1000 m; 40, 10, 3 and 1 are ratios to convert; L – distance (km).

We undertook an absolute bird count in the nesting period in order to determine the density of breeding birds and the overall density of Corvidae in the city.

We have distinguished several periods in terms of local weather patterns and the birds' life cycle: winter (November, 1 – February, 15), spring migration (February, 16 – March, 30), breeding (April, 1 – June, 30), post-breeding (July, 1 – August, 31) and autumn migration period (September, 1 – October, 30). The seasonal dynamics of the avifauna were examined in accordance with the selected periods.

Statistical data processing was performed by Statistica 6.0 (Statsoft Inc., USA). We used the Kolmogorov-Smirnov test to determine the normal distribution. The difference between the average was considered if the probability $P < 0.05$. The assessment of distress in linear relation was performed by using correlation analysis with Pearson correlation coefficient. To establish reliable statistical differences between samples we used t-Student test for independent samples and Fisher's criterion. The univariate analysis of variance was performed using procedures of one-way ANOVA. The regression analysis was performed in Multiple Regressions module within Statistica 6.0. The auto regression equations for bird density were calculated using Curve Expert 1.4; special software Trim 3.53 was applied for the calculation of trends.

Results

The breeding birds of the Corvidae family in Zhytomyr city were represented by 6 species, the dominant being the Rook. Its share was 68% (average density was 79.0 ± 3.7 birds/km^2, SD = 127.3). The European Jackdaw was the next most abundant species (12.5%), its average density in Zhytomyr was 14.5 ± 0.8 birds/km^2, SD = 28.6. The density of Eurasian Magpies was 10.2 ± 0.4 birds/km^2, SD = 13.2 (8.8%), Hooded Crows had a density of 9.2 ± 0.4 birds/km^2, SD = 13.5 (7.9%). The least numerous species were Eurasian Jay and Common Raven, the density of which were 1.9 ± 0.2 birds/km^2, SD = 6.2 (1.6%) and 1.4 ± 0.1 birds/km^2, SD = 4.9 (1.2%) respectively. The maximum density of corvids in Zhytomyr was registered in the winter period (Fig. 1). The most abundant winter species were Rooks and Jackdaws, which usually feed in mixed flocks and formed joint roosts.

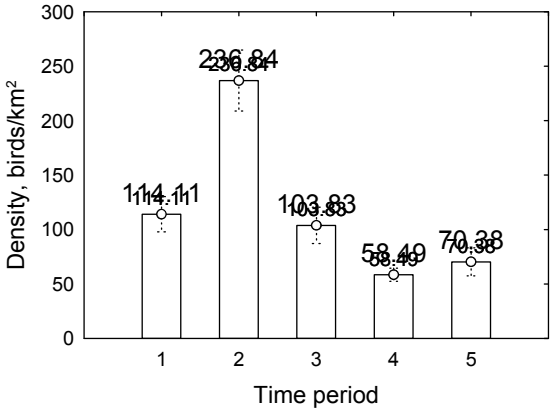

Fig. 1. The average seasonal density of corvids in Zhytomyr: 1 – autumn migration, 2 – winter, 3 – spring migration, 4 – nesting period, 5 – post-breeding period; mean and standard deviation

The Rook was the dominant species in all the urban habitats. The principal roosting cite for corvids was located in the military hospital and was occupied by birds from late October to early March. The number of birds on the coldest nights was around 13 thousand. There were some 4 peripheral roosting sites located along with Rooks' nesting colonies or near the central square. These sites operate in the summer-autumn period, and the number of Rooks and Jackdaws here reached 4 thousand.

The seasonal bird dynamics differed per habitat due to different degrees of human impact.

With increase in the urban gradient, the density of Rooks and Jackdaws significantly increased ($P < 0.05$), while the density of Hooded Crows, Jays, and Ravens decreased; the Magpie was distributed throughout the city more or less evenly.

The impact of urban gradient on Rook density is described by equation:

$$y = \frac{1}{ax+b},$$

where the correlation coefficient, $r = 0.79$; standard deviation, SD = 26.7; $a = -3.3$; $b = 2.4$.

The same dependence for Jackdaw:

$$y = \frac{1}{ax+b},$$

where $r = 0.81$; SD = 6.8; $a = -3.38$; $b = 2.3$.

The impact of urban gradient on Hooded Crow density:

$$y = a + bx + cx^2 + dx^3,$$

where $r = 0.99$; SD = 1.4; $a = 4.6$; $b = -3.0$; $c = 7.1$; $d = -4.8$.

The dependence for Magpie is:

$$y = a + bx + cx^2 + dx^3,$$

where $r = 0.97$; SD = 1.2; $a = -1.1$; $b = 2.7$, $c = -9.3$; $d = 9.4$.

The impact of urban gradient of density of Jays is described by the following equation:

$$y = axx^{\frac{b}{x}},$$

where $r = 0.96$; SD = 0.74; $a = 6.1$; $b = -4.8$.

The equation of Raven density towards the urban gradient:

$$y = \frac{a+bx}{1+cx+dx^2},$$

where $r = 0.84$; SD = 3.91; $a = 1.1$; $b = -3.6$, $c = -1.5$; $d = 4.9$.

Suburban green areas (buffer zones) are characterized by considerable diversity of Corvidae: this habitat was used by all species. It should be noted that the Raven was only registered in suburban forests, in the territory of the city dump and slaughterhouse waste. Quite a large population of Ravens was concentrated in a wooded area on the outskirts of Zhytomyr city adjacent to the city cemetery, where there were significant food resources. In this habitat we also observed the highest density of Jays and Hooded Crows; the large number of the former species could be explained by its invasion from the surrounding forests.

We surveyed a large concentration of Hooded Crows within the municipal Hydropark (13.4 birds/km^2), where they were registered in winter and breeding period. This can be explained by the proximity of the river Teterev, since the crows tend to live in watershed areas. Hooded Crows formed a great roosting cluster in spring, summer, and autumn in the territory of the Hydropark, whereas the central winter roost-

ing site was situated in the city park, here we registered up to 800 birds. We registered Jays in these zones only in influxes during the summer and autumn migrations.

The population density of Rooks in green suburban areas decreased significantly in 2011, as a result of human intervention into the large colonies, which were located in Hydropark in winter and spring of 2011–2012. Normally their numbers grew during migration periods when Rooks often fed on agricultural fields located on the outskirts of the city.

We fixed the significant density of Ravens in green spaces within the city center, especially during the breeding season. The breeding density of Rooks was at its maximum in these habitats, as 6 of 12 identified Rook colonies were located here.

The urban green areas attract nesting Magpies, Jays and Hooded Crows, while Jackdaws occurred here only in autumn and winter, when they foraged together with Rooks on the lawns of gardens and parks. The density of Ravens in habitats with green areas decreased with the establishment of stable snow cover, due to the depletion of food resources.

The individual buildings habitat was characterized by the lowest density of all the species. Even the common species (Rooks, Jackdaws, Hooded Crows) were in low numbers here due to the poverty of food resources, lack of places for large roosting flocks and scarcity of suitable nesting sites. However, the density of Magpies in this habitat was one of its highest (12.8 birds/km^2) densities for any urban habitat. The Magpie was found in habitats with private buildings all year round and successfully nested in the yards of private houses and in street trees, where its nest density was 11.2 birds/km^2.

The Jay was rather common in this habitat, its average density was 1.6 birds/km^2, with peak numbers in the spring migratory and nesting periods.

We observed the largest number of corvids in the old quarters of the multi-storey buildings zone, especially in the downtown area (Table 1). Here we also registered the largest number of Rooks (133.1 birds/km^2), Hooded Crows (36.4 birds/km^2) and Jays (12.8 birds/km^2), which were attracted by the rich food supply in the form of garbage containers with food waste and by availability of suitable nesting habitats.

Table 1

Seasonal pattern of Corvidae density in urban habitats

Habitat	Period*	Density, birds/km^2					
		Rook	Eurasian Jackdaw	Hooded Crow	European Magpie	Eurasian Jay	Common Raven
Urban green belt	1	84.6	6.2	26.8	8.6	5.8	7.8
	2	20.3	8.0	27.0	4.1	3.9	7.1
	3	9.7	–	18.6	8.7	3.1	9.0
	4	7.2	–	13.4	8.8	7.5	5.9
	5	104.2	0.3	23.1	15.6	13.1	3.8
Urban parks and gardens	1	91.9	19.9	8.1	9.2	1.3	–
	2	116.4	13.8	7.0	7.6	1.7	–
	3	46.3	8.8	8.1	7.0	1.3	–
	4	128.5	3.9	7.1	8.2	1.7	–
	5	81.5	13.5	4.9	5.3	3.8	–
Cottages (individual buildings)	1	35.6	1.0	2.8	12.5	0.8	–
	2	85.6	8.2	5.4	14.3	1.8	–
	3	34.4	4.1	7.5	10.5	2.3	–
	4	11.7	2.1	3.5	11.2	1.5	–
	5	11.5	1.8	1.1	16.9	1.5	–
Old 2–5-storey houses	1	131.4	35.3	13.5	6.8	1.8	–
	2	363.0	61.8	18.6	9.9	2.8	–
	3	118.2	45.9	14.5	9.9	1.6	–
	4	44.7	24.0	9.4	9.1	1.0	–
	5	33.9	20.5	10.2	6.0	0.5	–
9-storey buildings	1	84.1	14.2	5.6	4.5	0.3	–
	2	367.9	48.4	9.2	11.3	0.5	–
	3	87.2	8.4	5.8	7.7	–	–
	4	19.0	2.8	6.7	8.2	0.2	–
	5	33.8	13.1	6.1	12.6	–	–
Industrial area	1	75.8	14.7	7.8	8.5	0.3	5.7
	2	240.6	29.2	18.3	14.7	0.6	14.4
	3	89.8	32.3	17.0	21.2	0.4	13.9
	4	21.5	6.8	6.2	15.5	0.4	9.9
	5	26.8	10.9	4.6	8.1	–	4.9

Note: * – time period corresponds with that of Figure 1, "–" – means missing data.

The Hooded Crows usually nest in tall trees situated in multi-storey blocks, often at a distance of 10–15 meters from the buildings. Although the main breeding habitats of Rooks are small squares, parks, and urban boulevards, they fed in surrounding habitats with old buildings in the downtown area, attracted primarily by garbage and lawns between the houses. The Jackdaw is known as a typical rock species but tends to live in objects of urban architecture, which can serve as a substitute for natural rock nesting niches. In the urban area the birds occupy wall cracks and holes, attics, ventilation passag-

es, which are most common in 5-storey and 2–3-storey buildings of old municipal housing.

We counted maximum density of corvids in old building zone habitats in winter. The density of Rooks in this period was 363 birds/km^2, Jackdaws – 61.8, Hooded Crows – 18.6, Magpies – 9.9 and Jays – 2.8 birds/km^2. We should mention that the density of all the species decreased with the onset of spring due to the migration outflow.

The high number of Corvidae was also characteristic for habitats in typical 9-storey building zones. Thus, the average density of Rooks was 108.8 birds/km^2, Jackdaws – 15.5, Hooded Crows – 6.8, Magpies – 8.7, Jays – 0.2 birds/km^2 and this reached peak values in winter. Thus, the average winter Rook density was 367.9 birds/km^2, Jackdaws – 48.4, Hooded Crows – 9.2, Magpies – 11.3 birds/km^2.

It is significant that the one of the lowest corvid densities was during the breeding period in the new multi-storey building zones. The density of Rooks was 19 birds/km^2, Jackdaws – 2.8, Hooded Crows – 6.7, Magpies – 8.2 birds/km^2. This could be explained by lack of appropriate nesting habitats: the new panel and brick 9-storey buildings have few niches that are suitable for nest building, there is lack of high trees within the new blocks, which limits the distribution of corvids.

The habitats in the area of industrial development attract corvids all year round, thus in the landfill waste the density of Corvidae was 136.9 birds/km^2. The territory of the slaughterhouse was characterized by large concentrations of birds, especially in winter when we observed five species (Rook, Hooded Crow, Jackdaw, Magpie, Raven) with a total density of 1,578.5 birds/km^2. In spring, the population density of corvids at the factory declined sharply (by nearly 3 times compared to winter). In breeding season, the number decreased even more, and only the numbers of Hooded Crow and Magpie remained more or less stable. The latter in this period sometimes became a dominant species as it nests in territories around the slaughterhouse (the distance between adjacent nests can even be 0.5 meters).

Some of the winter Raven population also nested near the slaughterhouse, the birds built nests on the observation rail towers and one nest was found on the damaged buildings of the company. The distance between the nests did not exceed 50 m, which can indicate some changes in the breeding pattern, i.e. the transition from single to semi-colonial and group nesting.

In summer the importance of the slaughterhouse in the corvids' life cycle decreased, but the number of Rooks and Jackdaws slightly increased compared to the nesting period. The density of Ravens at the site was low in summer and in some years they were totally absent. The number of Corvidae at the factory was 8 times lower than during the winter period, due to the availability of food objects in other habitats.

In autumn food resources in natural biocoenoses are significantly reduced, while the working activity in the slaughterhouse becomes more intensive, hence the amount of food available for corvids increased, which caused the growth in numbers by 2.2 times compared to summer. Thus, meat processing plants in urban environments have a very important impact on birds as a forage base in winter.

Another important object that allows corvids to winter in cities, supporting large numbers, is dump solid waste. These are very specific habitats, which are usually located near cities and have a rich food base. They attract Corvidae, which form large concentrations in a limited area. At the rubbish dump (though it was rather a landfill) we registered some 5 species: Rooks, Jackdaws, Hooded Crows, Magpies, and Ravens. Their numbers varied in different seasons ($P < 0.05$).

The dump was mostly visited by birds in the winter months, with the peak number in February, because this time was extremely cold and snowy during 2009–2012. We registered a significant dominance of Rooks and Jackdaws in this habitat. The number of corvids at the landfill declined sharply during the breeding season, mainly due to the lack of suitable nesting places. At this time it was highly inefficient for Corvidae to feed outside the city due to the energy costs involved, and only non-breeding birds continued to feed in the landfill during this period. Corvidae faced stiff competition from gulls, which almost completely displaced them from the landfill during the nesting period. The minimum number of birds was observed in July and August, during which months, we did not register Ravens, Rooks, and Jackdaws. Obviously, anthropogenic food does not play such an important role in corvids' lives in summer.

During three years of research (September 2009 – August 2012) the density of all the Corvidae except the European Magpie did not change noticeably, although we revealed some positive trends (Table 2) that could be explained by invasion of migrants from more northern regions.

Table 2

Trends and average density of Corvidae

Species	Density, birds/km^2			Trend
	2009–2010	2010–2011	2011–2012	
Rook	67.0	83.7	87.0	0.13; moderate increase ($P < 0.05$)
Eurasian Jackdaw	11.4	14.6	18.0	0.23; strong increase ($P < 0.01$)
Hooded Crow	8.2	9.4	10.0	0.09; strong increase ($P < 0.05$)
European Magpie	9.6	10.5	10.3	0.03; uncertain
Eurasian Jay	1.4	1.9	2.3	0.25; strong increase ($P < 0.01$)
Common Raven	1.2	1.3	1.7	0.17; strong increase ($P < 0.05$)
Total density	99.0	121.2	129.0	0.13; strong increase ($P < 0.01$)

Discussion

The large concentration of Corvidae in urban habitats can be explained by the availability of fodder in the form of food waste, mild winter weather conditions and less pressure from animal predators (Mac Nally, 2000; Zeller and Schuffernecker, 2004; Anderies et al., 2007; Grimm et al., 2008; Conole and Kirkpatrick, 2011; Ramalho and Hobbs, 2012). The growth in density and abundance of the dominant species (Rooks, Jackdaws and Hooded Crows) in the Zhytomyr area, distribution of Magpies in uncharacteristic habitats (9-

storey building zones), colonization of densely populated city neighborhoods by the Jay, which used to be considered to be a typical forest dweller, together with the increase in the Raven population within the urban outskirts and near the landfill prove the intense sinurbanization of Corvidae in the modern conditions of Zhytomyr city.

When spring begins the number of Corvidae gradually declines, due to the departure of migrant birds that winter in cities, whereas after the breeding period Corvidae density increases due to the arrival of young birds, as also mentioned by other researchers (Donchev and Pyankov, 1989; Clergeau et al., 1998; McDonnell and Hahs, 2008; Ciach, 2012; Laband et al., 2013; Leveau, 2013). However, in mid-summer the numbers of Corvidae remain quite low, because in this period they migrate to surrounding natural habitats and they return to town for the winter after autumn begins.

The suburban green areas (buffer zones) are characterized by considerable diversity of Corvidae species: this habitat was used by all breeding species. Here we observed the highest density of Jays and Hooded Crows. The green spaces in the city center were also characterized by a high density of corvids, especially during the breeding season. The Rooks' nest density reached its maximum here (here were 6 of 12 identified colonies of Rooks in Zhytomyr). Jackdaws occurred here only in autumn and winter, when they used this area as a feeding habitat together with Rook flocks. With the establishment of stable snow cover, the density of corvids in green areas decreased due to the depletion of food resources.

The individual buildings habitat was characterized by the lowest density of all species. The number of Rooks, Jackdaws, and Hooded Crows was low due to limitation of food resources, lack of sites for large roosting flocks and scarcity of suitable nesting sites. However, Magpies reached one of their highest densities in this habitat (12.8 birds/km^2). This species was registered here all year round; its nest density was 11.2 birds/km^2.

Conclusion

The Rook was the most abundant species in urban habitats followed by Eurasian Jackdaw, European Magpie, Hooded Crow. The Eurasian Jay and Common Raven were characterized by considerably low densities. In winter we registered maximum numbers of Eurasian Jackdaws and Rooks which formed mutual feeding and roosting congregations.

The urban green belt seemed to be the most attractive for corvid distribution as well as green plots within the city center while the cottage area was characterized by low density with the exception of Magpies and Jays.

During the study period we registered slight positive trends for all corvids except for European Magpie, although it had a tendency to growth to some extent. Some increase of Corvidae density and abundance was probably caused by increased density of the wintering populations or due to increasing number of migrants from northern regions.

References

Anderies, J.M., Katti, M., Shochat, E., 2007. Living in the city: Resource availability, predation, and bird population dynamics in urban areas. J. Theor. Biol. 247, 36–49.

Blair, R.B., Johnson, E.M., 2008. Suburban habitats and their role for birds in the urban-rural habitat network: Points of local invasion and extinction? Landscape Ecol. 23, 1157–1169.

Bonier, F., Martin, P.R., Wingfield, J.C., 2007. Urban birds have broader environmental tolerance. Biol. Lett. 3, 670–673.

Catterall, C.P., 2009. Responses of faunal assemblages to urbanisation: Global research paradigms and an avian case study. In: McDonnell, M.J., Hahs, A.K., Brueste, J.H. (eds.) Ecology of cities and towns: A comparative approach. Cambridge University Press, New York. P. 129–155.

Chace, J.F., Walsh, J.J., 2006. Urban effects on native avifauna: A review. Landscape Urban Plan.74, 46–69.

Ciach, M., 2012. The winter bird community of rural areas in the proximity of cities: Low density and rapid decrease in diversity. Pol. J. Ecol. 60, 193–199.

Clergeau, P., Savard, J.P.L., Mennechez, G., Falardeau, G., 1998. Bird abundance and diversity along an urban-rural gradient: A comparative study between two cities on different continents. Condor 100, 413–425.

Conole, L., Kirkpatrick, J.B., 2011. Functional and spatial differentiation of urban bird assemblages at the landscape scale. Landscape Urban Plan. 100, 11–23.

Ditchkoff, S.S., Saalfeld, S.T., Gibson, C.J., 2006. Animal behavior in urban ecosystems: Modifications due to human-induced stress. Urban Ecosyst. 9, 5–12.

Donchev, S.I., Pyankov, P.N., 1989. Status and trends synantropyzatsyy and synurbyzatsyy birds in Bulgaria. Ecology 22, 35–42.

Evans, K.L., Chamberlain, D.E., Hatchwell, B.J., Gregory, R.D., Gaston, K.J., 2010. What makes an urban bird? Glob. Change Biol. 17, 32–44.

Evans, K.L., Newson, S.E., Gaston, K.J., 2009. Habitat influences on urban avian assemblages. Ibis 151, 19–39.

Fernandez-Juricic, E., Jokimäki, J., 2001. A habitat island approach to conserving birds in urban landscapes: Case studies from southern and northern Europe. Biodivers. Conserv. 10, 2023–2043.

Grimm, N.B., Faeth, S.H., Golubiewski, N.E., Redman, C.L., Wu, J., Bai, X., Briggs, J.M., 2008. Global change and the ecology of cities. Science 319, 756–760.

Hundson, W.H., 1998. Birds in London. Longmans Green and Co., London.

Jerzak, L., 1995. Breeding ecology of an urban Magpie *Pica pica* population in Zielona Góra (SW Poland). Acta Ornithol. 29, 123–133.

Jokimäki, M.-L., Hakkarainen, H., Huhta, E., Inki., K., Suorsa, P., 2009. Urbanization and stability of a bird community in winter. Ecoscience 16, 502–507.

Laband, D.N., Lockaby, B.G., Zipperer, W.C., 2013. Urban-rural interfaces: Linking people and nature. American Society of Agronomy, Soil Science Society of America, Crop Science Society of America, Inc. Madison, USA.

Leveau, L.M., 2013. Bird traits in urban-rural gradients: How many functional groups are there? J. Ornithol. 154, 655–662.

Luck, G.W., Smallbone, L.T., 2010. Species diversity and urbanization: Patterns, drivers and implications. In: Gaston K.J. (ed.) Urban ecology. Cambridge University Press, Cambridge.

Mac Nally, R., 2000. Regression and model-building in conservation biology, biogeography and ecology: The distinction between and reconciliation of 'predictive' and 'explanatory' models. Biodivers. Conserv. 9, 655–671.

Marzluff, J.M., Bowman, R., Donnelly, R., 2001. A historical perspective on urban bird research: trends, terms, and ap-

proaches. In: Marzluff, J.M., Bowman, R., Donnelly, R. (eds.) Avian ecology and conservation in an urbanizing world. Kluwer Academic, Boston. P. 1–16.
Marzluff, J.M., Rodewald, A.D., 2008. Conserving biodiversity in urbanizing areas: Nontraditional views from a bird's perspective. Cities and the Environment 1(2), article 6.
McDonnell, M.J., Hahs, A.K., 2008. The use of gradient analysis studies in advancing our understanding of the ecology of urbanizing landscapes: Current status and future directions. Landscape Ecol. 23, 1143–1155.
Matsyura, A., Jankowski, K., Zimaroeva, A., 2015a. Corvidae tolerance to human disturbance in settlement landscapes of Zhytomir (Ukraine). Romanian Journal of Biology – Zoology 60(1), 39–47.
Matsyura, A., Jankowski, K., Zimaroeva, A., 2015b. Escape behaviours of Corvidae in an urban ecosystem of Zhytomyr (Ukraine). Romanian Journal of Biology – Zoology 60(2), 125–134.
Matsyura, A.V., Zimaroyeva, A.A., 2016. Osobennosti prostranstvennogo raspredeleniya voronovykh v usloviyakh transformirovannykh landshaftov Zhytomyrskoy oblasti [Spatial distribution of Corvidae in transformed landscapes of Zhytomyr area]. Vìsn. Dnìpropetr. Unìv. Ser. Bìol. Ekol. 22(1), 53–59 (in Russian).
Møller, A.P., 2009. Successful city dwellers: A comparative study of the ecological characteristics of urban birds in the Western Palearctic. Oecologia 159, 849–858.
Møller, A.P., Diaz, M., Flensted-Jensen, E., Grim, T., Iba'nez-Alamo, J.D., Jokimaki, J.-M., Marko, G., Tryjanowski, P., 2012. High urban population density of birds reflects their timing of urbanization. Oecologia 170, 867–875.
Ramalho, C.E., Hobbs, R.J., 2012. Time for a change: Dynamic urban ecology. Trends Ecol. Evol. 27, 179–188.
Ruszczyk, A., Rodrigues, J.J.S., Roberts, T.M.T., Bendati, M.M.A., Del Pino, R.S., Marques, J.C.V., Melo, M.T.Q., 1987. Distribution patterns of eight bird species in the urbanization gradient of Porto Alegre, Brazil. Ci'encia e Cultura 39, 14–19.
Savard, J.P.L., Clergeau, P., Mennechez, G., 2000. Biodiversity concepts and urban ecosystems. Landscape Urban Plan. 48, 131–142.
Strohbach, M.V., Haase, D., Kabish, N., 2009. Birds and the city: Urban biodiversity, land use, and socioeconomics. Ecol. Soc. 14, 31.
Tratalos, J., Fuller, R.A., Evans, K.L., Davies, R.G., Newson, S.E., Greenwood, J.J.D., Gaston, K.J., 2007. Bird densities are associated with household densities. Glob. Chang. Biol. 13, 1685–1695.
Zeller, H.G., Schuffernecker, I., 2004. West Nile virus: An overview of its spread in Europe and the Mediterranean basin in contrast to its spread in the Americas. Eur. J. Clin. Microbiol. Infect. Dis. 23(3), 147–156.

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