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THE ASSESSMENT OF THE KYIV URBAN ECOTOPES COMFORT AS A BIRDS' HABITAT

The city is one of the most specific ecosystems of the modern biosphere. The combination of natural and artificial components and elements of the city have made it a complex system of ecotopes with various levels of anthropogenic transformation. Still the structure of urban ecosystems includes some patches of undisturbed or minimally disturbed landscapes, which may be considered the home for the most abundant part of urban biocenosis – the urban avifauna. Therefore, in this research the concept and features of urban zoocenosis in specific application to avifauna of the Kyiv urban system have been considered. A modern city is found to offer a range of benefits for birds, including food, shelter, and higher temperatures over the year and lower predator pressure and competition. However, the level of food quality as well as the condition of environment components are low and impose real health threats. Physical pollution, in particular noise and electro-magnetic impacts are also serious disturbing factors. Considering these factors, the ecotopes most suitable for birds have been defined among the parks, forests, lakes and cemeteries of the city – total 59 objects. In order to assess their comfort for birds, the specific ranking scale has been developed. The parameters taken into consideration in the course of assessment are as follows: general spatial characteristics (size and fragmentation of the territory), vegetation quality (covered territory, height and age of trees), forage availability and diversity, hydrographic situation (access to water bodies), environment quality (level of water and air pollution, noise pollution, non-organic wastes directly at the site), human pressure (density of people moving, area with artificial covers, level of anthropization), bird supporting elements and activity, and also predation pressure. According to the obtained result the forests around and its residuals inside Kyiv are the least transformed and consequently the most comfortable for the support of birds diversity. They are followed by cultivated semi-natural areas, which comfort declines as the levels of recreational pressure, human presence and proximity to the city center increases. Finally, the last in the list are small parks or cemeteries, cut off from water bodies or water bodies lacking dense vegetation. An important issue, showed by personal visual observations, is that the activity of humans aimed at support of birds communities within area of any status is proved to be more important as compared to obvious disadvantages seen at certain areas.

Keywords: avifauna; bird communities; ecotope; habitat comfort; anthropogenic transformation; anthropogenic pressure.

Introduction. Around the world most of urban ecosystems express a common trend in their species diversity, which is basically another element of globalization: as urban settlements generally have similar structures and manifest similar features, the wildlife presence also becomes similar. In general, those are the species that are more adapted and tolerable to changes imposed by cities upon their natural habitats. The synanthropic species live in close interrelations or even direct dependence on the urban mode of life, as well as the invasive alien species, introduced to cities everywhere and now are becoming more and more inseparable from those systems. As a result, urban wildlife is usually represented by the minority of species that would normally inhabit the area.

However, city is a complicated habitat to live in, as it includes various threats for wildlife. Fragmentation, loss or dynamic transformation of natural areas leaves no time for adaptation. The increased environment pollution is dangerous for most living organisms, as well as risk of transport collisions and influence of physical factors, reduced quality

of food. The removal of native species from urban areas and their replacement with non-native species increases competition and leads to homogenization of biodiversity. On the other hand the food is available in big quantity, predators are not diverse and specified and climate extremes are mitigated. Certain studies performed on urban avifauna also proved the tendency of city birds having bigger brain size, perhaps allowing them to be more adaptable to the changeable urban environment (Møller & Erritzøe, 2015). Arguably that can be a modern manifestation of evolutionary selection of the "fittest", altered and directed by humanity and its development.

Yet, despite the general trends, different types of urban areas still support different kinds of wildlife. In this regard it is important to evaluate the comfort of urban habitats and ecological niches available for wildlife. The presented research is aimed at the assessment of the Kyiv city habitats suitability for typical avifauna. The researches work within this field of study in three major directions: study of the diversity and condition of the urban fauna (Warren, 2019),

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evaluation of the risks for certain group of organisms within a specific urban area (Leal, 2019) and the perspectives for conservation of the urban fauna representatives within a city (Flores-Meza, 2013; Rastandeh et al, 2018). None of such research works are available for Kyiv in detailed form, so there is a need to elaborate the approaches and perspectives of the urban animal world support in Ukraine.

City as an ecotope. Although the urban ecosystems have been largely ignored throughout many decades of environmental research, they are currently considered as those that are structured and function like other natural ecosystems (McDonnell & Pickett, 1990; Grimm et al., 2000; Collins et al., 2000). In the light of continuous expansion of artificial domain and conversion of natural lands, urban environments can no longer be viewed as a lost habitat for wildlife, but rather as a new habitat. With proper management it has the potential to support diverse communities (including avian ones) (Miller & Hobbs, 2002; McKinney, 2002; Rosenzweig, 2003).

In the scientific community, there is still no consensus on what to understand under the definition of "ecotope". Ecotope, in its original meaning, proposed by G. Vysotsky, was understood as a part of the earth's surface with a relatively homogeneous unchanged complex of abiotic environmental conditions. Since the introduction, the term has undergone several alterations as of its interpretation proposed by other scholars. For example, V. Sukachev did little to distinguish the concepts of "ecotope" and "biotope", stating that ecotope is a set of all elements of a biotope that constitutes an environment of the existence of a biocenosis (Didukh & Alioshkina, 2006). A number of other scientists use the term to denote external conditions of existence that are not related to biocenotic environment, or equate it with the term "environmental habitat" (Meyer, 2000; Riu-Bosoms et al., 2015). Whittaker et al. (1973) stated ecotope as the species relation to the full range of environmental and biotic variables affecting it, – which causes a confusion between terms "ecotope" and "environmental niche".

Foreign scientists often do not include the term in the field of knowledge of general ecology, utilizing it in relation to the issues of geography and landscape ecology. Arthur Tansley elaborated the definition as the particular portion of the physical world that forms a home for the organisms, which inhabit it. In his turn, Carl Troll was the first, who adapted the term to the field of landscape ecology, stating that ecotope is "the smallest spatial object or component (portion) of a geographical landscape" (Willis, 1997). Further, the term "ecotope" has been replaced with the term "patch", while adapting and changing the original meaning and defining patch as a nonlinear surface area differing in appearance from its surroundings (Foreman & Gordron, 1986; Ingegnoli, 2002).

All in all, two definitions can be picked for the current work. First one elaborates on ecotopes as the smallest environmentally homogenous and separated set of landscape features in mapping and classification system, or, in short, smallest distinct landscape that can be used as a functional unit for some kind of scientific activity. Second one defines ecotope as a complex of environmental features (air, water, soil, climate regimes, mineral nutrition etc.) which are present on distinct homogenous spatial portion of surface. While those definitions are somewhat close and related, we

will utilize the second one, as the work considers more environmental than landscape and geographical context.

According to the definition of choice, ecotope is composed of 3 (or 4) major elements: climatope, hydrotope and edaphotope (or pedotope and morphotope, which are, basically, the structural elements of edaphotope). Accounting the level of anthropogenic transformation of all components of urban environment, the ecotops of any city are strongly different from those formed due to geographical location at the given territory, as their chemical composition, physical and morphological parameters are deviated from original ones. Moreover, the intensity of changes is not even within the city and a city in itself is rather a system of higher order or system of ecotopes.

The well known is the fact, that Kyiv is in unique conditions, placed literally on the border between two quite distinct natural areas of Ukraine – zone of mixed forest or Ukrainian Polissya and forest-steppe zone. However, it doesn't allow attributing common inhabitants of those regions to the Kyiv area as well meaning that areas of wildlife population of those zones include city territory and potentially all of them could be encountered there too. This is obviously not the case as the city is lacking certain natural conditions obligatory for some species. This raises the degree of uncertainty and inaccuracy, giving us very blurry image of urban avian species diversity. Another important issue is that most studies about the urban fauna focus on the protected areas, threatened and protected fauna and habitats composition, which eventually provides incomplete information. However, the urban environment is very complex, and there is always a risk to obtain incomplete data and to leave out something important. Yet another distinctive, but similar feature of the habitats, defined under the different approaches, is their undeniable connection to the Dnipro river or other water bodies. Thus, in our research the geographical context of the objects to study is based on water bodies of various types, but predominantly lakes as the most abundant and well inhabited by birds.

Methods and materials. As our work concentrates on specific fauna component of urban systems and its place in it, this drives us to determination of the basic units, in other words the smallest ecotopes, suitable for further analysis. The most classical approach is the one proposed by the European Nature Information System (EUNIS) as a part of task of the European Environment Agency for sustaining and reporting of the European Environmental Information Observation Network as well as nature protection networks of NATURA2000 and EMERALD. The apparatus of this approach is mainly attributive-descriptive. The scheme for classification does not envisage single criterion for the ecotope distinction. Depending on the hierarchical level and belonging to the natural or urban system type, different criteria are chosen: the dominance of a biotic or abiotic factors, type of land use etc. The fullest and more or less successful EUNIS classification for Kyiv city was performed by Y. Didukh and U. Alioshkina (2006).

Accounting the important factors for the support of avian communities, we have elaborated the list of ecotopes in Kyiv, which pose more or less comfortable conditions for bird populations by essential limiting factors in urban ecosystem, which are living space, nutrients availability and anthropogenic pressure. The level of fragmentation has been a dominant factor in the choice of ecotopes, so that the

selected areas are wholesome. The industrial areas and residential blocks were excluded from the research as the level of their habitability is lower and meets the requirements of the most ubiquitous species.

The next step of the process is the analysis of the comfort with a set of criteria, developed specially for this task. The chosen ecotopes have been evaluated via the methodology of rating scales (grades 0-1-2-3 have been set in details for fixed ranges of indicators values) by the following list of adaptation indicators:

- A – General spatial characteristics: A1 – overall size of the territory; A2 – level of fragmentation;
- B – Site vegetation: B1 – share of the territory covered with stable vegetation; B2 – average height of the trees; B3 – average age of the trees;
- C – Forage situation: C1 – density and abundance of insect populations; C2 – abundance of and proximity of cereal plants; C3 – abundance of and proximity of fruit plants; C4 – proximity to human refuse wastes, excluding packaging materials;
- D – Hydrographic situation: D1 – availability of and proximity to water bodies; D2 – free access to water bodies;
- E – Environment quality: E1 – water pollution; E2 – air pollution; E3 – non-organic wastes directly at the site;
- F – Human pressure: F1 – overall level (intensity) of anthropization: area, covered with pavement and occupied with buildings; F2 – level of disturbance, human presence at the site and recreational activity; F3 – typical noise pollution of the area;
- G – Bird supporting elements and factors: G1 – availability and level of development of supporting infrastructure; G2 – informational work at the territory, awareness raising, information stands about species of the site, rare/ endangered/protected species as well as ways to be of service to them, improve their living conditions and life quality and/or simple rules of behavior; G3 – presence and/or availability of ornithological service at the site, or any kind of site administration and their contact information available; G4 – auxiliary shelter and warmth available through harsh weather conditions, e.g. increased heat radiation in cold seasons; G5 – reservation status of the territory (if area is protected or not);
- H – Predation pressure; availability and abundance/density of natural predators – feral species or carnivorous bird species etc.

Results and discussions. For a very long time the city of Kyiv has been generally acknowledged "the greenest European capital". As the city progresses throughout the years, develops and expands, this status becomes questioned. But what does the notion of "the greenest city" implies in terms of ecosystem quality? Apart from having the greatest percentage of vegetation, does it include being the most sustainable, eco-friendly or comfortable for most nature representatives – that is the real question, partially answered in the given research. The area of the city is huge and diverse, but eventually accounting all the important criteria 59 objects have been defined as potentially suitable and integral habitats.

Out of this list those most adapted for birds have been chosen and the rating of adaptation and comfort has been defined based on the above presented indicators (Table 1). Here we can see, that the ring of forests around and its residuals inside Kyiv (Holosiivsky NNP, Pushcha-Vodytsia, Pyrohiv and Feofania park and garden complex, Almazne lake and Lisove cemetery, Koncha Zaspа, Darnytskyi forest and Sviatoshynskyi forest), being the wildest city territories, are the most comfortable and sustainable and fit for supporting various species in essential numbers. This predictable result is another prove of the fact, that even the reduced predator pressure, more comfortable temperature and availability of food are still less attractive, than natural non-disturbed conditions. It is also important to note that possible disappearance of these areas will have a deteriorating effect on the whole urban zoocenosis due to the "edge effect". Then they are followed by cultivated semi-natural areas, the comfort of which declines as the levels of recreational pressure, human presence and proximity to the city center increases – from well adapted Fomina Botanical Garden and Shevchenko park, Hryshko Botanical Garden, Sviatoshyn Lake network and Trukhaniv isle to the Dnipro river isles and embankment. Finally, the last in the list are mostly rather small parks or cemeteries, cut off from water bodies or water bodies lacking dense vegetation, for example, Protasiv Yar and Kuchmin Yar.

Table 1. Total rating of the urban ecotopes' comfort for the birds' living activity

№	Object	Sum of points	№	Object	Sum of points
1	Bortnychi	23	20	Park Nyvky	34
2	Darnytskyi forest	49	21	Syretsky park	30
3	Partisan Glory Park	39	22	Syrets and Park Dubky	37
4	Osokorky, Vyrlytsia and the lake network	28	23	Lukianivske and Viiskove cemeteries	28
5	Sviatoshynskyi forest (park)	49	24	Kyiv Zoo and Pushkin park	30
6	Trukhaniv isle	41	25	Victory Park	29
7	Hydropark	35	26	Kuchmin Yar	27
8	Almazne lake and Lisove cemetery	50	27	Protasiv Yar and Bozhkov Yar	28
9	"Muromets'park and Desenska river	29	28	Mariinsky, City and Khreshchatyi parks	30
10	Verbliud bay with lakes	27	29	Hryshko Botanical Garden	45
11	Pushcha-Vodytsia	51	30	Park of Eternal Glory	22
12	Kin'-Grust' area	30	31	Sovky	34
13	Zhukiv isle	37	32	Bold mountain	40
14	Berkovetske cemetery	31	33	Holosiivsky NNP	56
15	Fomina Botanical Garden and Shevchenko park	45	34	Pyrohiv and Feofania park and garden complex	51
16	Lake network (Sviatoshyn)	43	35	Dnipro river isles and embankment	33
17	Park Sovky	29	36	Koncha Zaspа	50
18	Saint Vladimir Hill	31	37	Kurenivske cemetery with Birch grove	31
19	Kyrylivskyi grove	33			

One interesting point worth mentioning is how positive human intervention drastically changes the situation for objects and sometimes plays the decisive role – Holosiivsky

NNP, though smaller and more cultivated than forest ring, still have the highest rating due to the work of the people and services of the park to the benefit of the birds.

Obviously, such an assessment entails a set of limitations – though evaluation was performed based on expert opinions, literature review as well as personal field surveys and evaluation, it still bears a burden of human factor, the list of indicators could be incomplete (e.g. light pollution hasn't been considered) and also differences in seasons play a considerable role in the situation. Also, the magnitude of some factors is more important for birds, then it could be supposed, for example, one of objects with the lowest rating in the assessment – Bortnychi, is in fact very much favored by birds especially in winter, due to the increased heat radiation, easily available nutrition, which means that birds in this situation ignore low environmental quality and human pressure of the site.

Of course, the presented list of the ecotopes and habitats available in the city borders is not complete and comprehensive. Yet we deem them the most relevant and significant for birds, as other niches are tightly intervened into urban residential and economic infrastructure and are not likely to sustain pairs or populations of birds other than synanthropic ones. Nevertheless, even with all its flaws, the results of the assessment still align very well with the overall expert opinions (Flores-Meza et al., 2013; Miller & Hobbs, 2002) regarding the best populated bird hotspots in terms of diversity and numbers.

Conclusions. Urban areas are still habitats of various species of wildlife and assessment of urban ecosystems quality cannot be complete without considering its comfort and safety for animals. At the same time diversity of natural conditions, level of environment pollution and anthropogenic transformation of urban environment makes modern cities a system of ecotopes different in their parameters.

Considering landscape conditions of the capital city, the list of Kyiv ecological niches, which are the most essential for city birds' populations, have been defined and differentiated according to the primary assessment of vegetation cover condition, size and anthropogenic pressure.

Further, the primary division is combined with personal field surveys to define the most suitable locations, which can really sustain bird populations. Then the list of indicators has been developed to characterize the quality of chosen areas in terms of their adaptation and comfort for avifauna. The results of the analysis confirm the importance of size, continuity, fragmentation, vegetation, foraging and water availability factors, while debunked the high influence of predation pressure and environment quality.

Furthermore, human presence and anthropogenic pressure have proved to be controversial – being both disturbing and supporting depending on the type of human activity. Moreover, the importance of beneficial human intervention for bird populations of city objects is an important argument in favor of expansion of protected areas network within the city with clearly set objective of birds supporting. Thus, there is need to continue the research on how the dynamics of bird populations will change at those territories which have been recently included into the list of protected areas of the city, as well as define the distribution patterns

for birds in terms of the levels of environment pollution in the city.

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ОЦІНЮВАННЯ КОМФОРТНОСТІ МІСЬКИХ ЕКОТОПІВ КИЄВА ЯК АРЕАЛУ ДЛЯ ПТАХІВ

Проаналізовано структуру сучасної міської екосистеми та місце у ній зооценозу. Встановлено, що міста є поєднанням незначних за площею, але різноманітних за своїми властивостями, елементів. У межах кластерів, що містять природні, напівперетворені або відновлені фітоценози, існує можливість для підтримки і розвитку міської орнітофауни. Для оцінювання потенціалу міста Києва як ареалу проживання птахів проведено дослідження 59 об'єктів цього типу. Проаналізовано основні загрози та переваги для орнітофауни в межах міських територій. Запропоновано спеціальну методику оцінки комфортності міських екотопів для птахів за основними показниками, що впливають на динаміку їх популяцій. Встановлено, що найсприятливішими є залишки лісових ділянок та паркові зони з мінімальною рекреаційною діяльністю. При цьому виявлено, що активна діяльність людей, спрямована на підтримку орнітофауни, може підвищувати привабливість інших об'єктів, навіть за умови їх теоретично меншої комфортності. Підтверджено неоднозначний вплив антропогенного навантаження на різноманіття птахів, що збігається з результатами інших дослідників. Для подальшого аналізу закономірностей розвитку міських зооценозів потрібно проаналізувати ситуацію на територіях, що нещодавно отримали заповідний статус, та тих, що характеризуються підвищеним рівнем забруднення.

Ключові слова: орнітофауна; спільноти птахів; екотоп; комфорт середовища проживання; антропогенна трансформація; антропогенне навантаження.