

Morphological and ecological preadaptations as the basis of bird synanthropization under transformed environment conditions

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Abstract. Bird synanthropization is connected with a thorough and serious reconstruction of their biology and is a demonstration of changes currently occurring in the biosphere due to human influence. Nutritional and nesting conditions as well as protection due to urban characteristics are advantage factors that affect their populations. Under these conditions, the adaptive potential of species can be realized. Adaptations to a new and in-distinctive environment appear due to preadaptations. The synanthropization process of species happens without speciation by expression of existing genetic variation of morphological and ecological characteristics.

Preadaptation, as A.Georgievsky notes [1], is an independent evolutionary phenomenon that involves readiness to express neutral or even relatively destructive characteristics; it is not a result, but it is one of the ways to develop new phylogenetic adaptations. Most of the statements about value of preadaptations are considered from the perspective of influence on species formation in micro- and macro-evolution processes. Due to the dynamics of urban conditions and their constant variability, the processes occurring in urbanized ecosystems and in populations of synanthropic birds do not allow considering synanthropization as speciation and the formation of exclusively urban species. But the synanthropization process itself is undoubtedly based on morphological, ecological, and behavioral preadaptations of individual species.

Bird synanthropization is connected with multiple features and seriously restructures the ecology of birds found in areas affected by anthropogenic factors, especially urbanized environments. At the same time, only a small portion of bird species become synanthropic, not all of them. Thus, for most cities of Tatarstan, the Middle Volga region and Russia in general, synanthropic birds are the rock pigeon (*Columba livia*), the black swift (*Apus apus*), the jackdaw (*Corvus monedula*), the house martin (*Delichon urbica*), the house sparrow (*Passer domesticus*) and the tree sparrow (*Passer montanus*). In some regions, three or four more species inhabit urban ecosystems and form synanthropic populations. Ecological characteristics of these species are associated with transformed territories, and their existence is mainly dependent on human influences. Nutritional and nesting conditions as well as protection by certain urban characteristics are some of the advantage factors affecting their populations. Under these conditions, adaptive potentials of species can be expressed [2].

Numerous researchers of birds in cities state that adaptations to unusual environments and realization of adaptive potential occur on the basis of preadaptations and synanthropization processes .



Preadaptations are widespread in nature and appear to be one of the most important ecological mechanisms of evolutionary processes [3]. Living organisms develop features which, under the control of natural selection, lead to formation of qualitatively new adaptations. Properties that have an adaptive value for a previously unrealized interaction between an organism and the environment or for functions not yet acquired by an organism are called preadaptive; the process of expressing a preadaptive trait is called preadaptation [4]. Anthropogenic environments present special demands for bird species inhabiting them and always depend on human activity; it is a habitat for species and populations whose reaction to changing conditions are consistent with potential opportunities of their biology. This is especially evident for the synanthropic birds of the cities of Western and Central Europe.

It is not entirely correct to say that bird synanthropization in West and Central Europe began earlier than in Eastern Europe. There are numerous known historical studies about of jackdaws, rooks, sparrows inhabiting cities even in the early historical periods of the formation of states and the construction of urban settlements in all Eastern Europe. But in the past 100–150 years, birds have penetrated and begun living in the cities of Western Europe.

The bird populations of Western and Eastern Europe have similar species but appear to be in different stages of synanthropization. The European jay (*Garrulus glandarius*), the ring dove (*Columba palumbus*), the European partridge (*Pedrix pedrix*) and many other representatives of western avifauna differ markedly in their behavior in anthropogenically transformed territories compared to populations of the same species from Eastern Europe. This indicates many potential opportunities of birds to exhibit adaptations in the process of their synanthropization. As noticed by S. S. Schwarz [3], a certain type of adaptation arises when the adaptations promote prosperity of a species when they are useful but not necessary. Development of such an adaptation enables a species to enter an environment where the adaptation is an essential condition for existence. For these reasons the synanthropization of eurybionts, with wider adaptive opportunities, occurs more actively. It is highly important for birds to be eurythropic and habitat versatile. Feeding with various types of food promotes colonization of anthropogenic environments by birds which are polyphages; they are attracted into the cities by available food resources. The main places of synanthropic birds concentration are dumps, food waste collection places, and agricultural ecosystems [5].

Before mastering the urbanized environment, birds were meant to have a minimum of adaptive features to the later appeared urban environment. Most of the typical synanthropic birds are characterized by wide potential in feeding and nesting, in other words they are preadapted to mastering the urbanized environment. Morphological preadaptations include: features of the structure of limbs and beaks, body size, and flying abilities. For birds, the structure of beak is an essential peculiarity for feeding. It is clearly demonstrated by a well-known example with Galapagos finches [6]. Such a specialization limits ability of a species to thrive on various types of food. Under anthropogenic environmental conditions, birds specialized in taking food particles from the ground or other solid surfaces are better adapted. For example, crows, thrushes, starlings, pigeons, sparrows share this trait in common. For comparison, the incurved beaks of birds of prey or long beaks of sandpipers and herons are not such a universal hunting tool. Long legs, necks, and tail-feathers acting as rudders are not so useful for living in urban landscapes. The size of a bird also limits penetration into anthropogenic landscape. However, it should be noted that morphological preadaptations can limit, but do not exclude, the appearance of some bird species, even in urbanized areas. The variety of conditions found near human activity might be acceptable in exceptional cases for highly specialized species, especially in response to unstable conditions. Populations of big birds of prey (kites and vultures) in the cities of India are well known [7].

A group of Swedish scientists came to an unusual conclusion; they studied more than 82 bird species in cities and outside them. Having surveyed more than 12 cities, they tried to figure out why some bird species are more adapted to live in cities. It turned out that urban birds have a brain which is larger in relation to the body than the brain of their conspecifics from outside the city. Studies have confirmed that there is a close relationship between behavioral innovations and enlarged brain size in

mammals and birds. The results strongly suggest that brain size is one of the critical factors contributing to the survival of animals in the city.

Ecological preadaptations involve ways of hunting and searching for food, nesting level, feeding level, aggregating behavior, migrating, and others. Behavioral preadaptations are associated with mutual tolerance of a species and humans, potential enemies, and birds from different ecological groups.

The method of obtaining food, in other words feeding behavior, undoubtedly plays an important role in the preadaptive capabilities of species. As noted, picking from solid surfaces is the most successful option for synanthropization of bird. But many observations indicate a wide range of ways of obtaining food. So, urban dumps are actively used by storks, marabous, and various gulls. During the plowing of the land are followed not only by rooks and jackdaws but also by sea gulls. A unique case was described in St. Petersburg. Seagulls were snatching pieces of bread in the air from woman on the balcony of a 5-story building. How can one explain such an uncharacteristic, at first sight, behavior of seagulls? The potential of preadaptive opportunities is big enough and, when needed, this preadaptation can be manifested. In a natural environment, most seagulls collect food on shore while ability to catch a food directly in flight can be observed when they take food from other birds [5].

During processes of urbanization, birds enter an urban territory and occupy specific ecological niches within a city. Often they are analogues of their natural biotopes, or niches that are completely unknown in natural ecosystems (urban dumps). As a biotic category, an ecological niche is characterized as an assembly of factors which support organisms' survival and their functional place in an urbancenosis. The variety of ecological niches determines the zoocenosis- stability of a city. The mosaic structure of urban biotopes creates extra opportunities for inhabiting a city by different bird species, and it also creates ecological niches for different groups of birds which are occupied by species belonging to different systematic groups. The penetration of a new environment happens by using already existing habitats with a set of conditions acceptable for a species' survival. Thus, inhabiting anthropogenic landscapes depends on biotopes as the analogues of natural habitats. According to the opinions of several authors, birds inhabit micro-environments of cities that resemble their native niches [8, 9]. Conservation of natural habitats within the city accelerates entrance of many species into anthropogenic landscapes. They serve as buffer and transitional zones for most of potential synanthropes. Thus, the currently observed, wide-spread range of mallard duck (*Anas platyrhynchos*) is due to preadaptive capabilities of these species and lack of chasing by people.

The most important stage of bird species synanthropization is nesting in anthropogenic landscapes. Nesting in anthropogenic landscape is an indicator of the favorable conditions for species within parts of anthropogenic landscape. There is no species that could begin to reproduce in anthropogenic landscape before it acquired a complex of trophic connections. Reproduction in a transformed territory has its own special aspects, because it occurs with changes of some standard nesting characteristics [10]. The changes in reproductive biology are shown in the elongation of a reproductive period, in the change in the number of clutches, and increased fertility. Nesting techniques and some behavioral aspects during the reproductive period are subject to change. In anthropogenic landscapes, birds exhibit unusual nest-building, uncommon location, the use of anthropogenic materials to build a nest, and other features. Due to environmental change in urban areas prolongs feed availability, suitable places for nesting, and the reproductive period of some species, sometimes by large amounts. This, however, is not a complete list of preadaptive features of birds which are on their way to synanthropization [11].

The most favorable nesting and natural conditions of birds belonging to the rupicolous complex are close to that of urban environment. This complex is wide spread and mostly specific for cities (rock pigeons, swallows and swifts). The historical process of city colonization by these species has existed for the longest in time, and it is represented in all adaptations of a given group through readiness to nest. Birds of the rupicolous complex easily find suitable places for nesting under urbanized conditions. The range of species of urban birds associated with the tree and shrub layer is less defined. For the Middle Volga cities, they are the chaffinch, the goldfinch, the linnet, the great tit, the collared

turtledove and other species, which nest in tree plantations. They actively populate park and garden biotopes and invade available ecological niches, even disturbed ones, which are close to their natural analogues. In cities of Central and Western Europe, the niches of birds involving tree and shrub layers are inhabited by the blackbird, the ring dove, the collared turtle dove, the common jay and other species that are not characteristic of urbanized territories in the east of the European part of Russia and that rarely fly into cities. Thus, different cities of various geographical regions have similar ecological niches which are occupied in each specific case with a different set of species. Semi-aquatic birds need special conditions, however. For example the mallard duck, the seagull, the blue-throated robin and several other species often nest in urban areas with lakes, rivers, or other water bodies. Terrestrial birds that inhabit open biotopes have fewer advantages in urbanized ecosystems. The characteristics of urban localities and urban planning practices exclude large spaces of waste grounds and undeveloped lands. The ecological niches of open biotopes remain unoccupied due to strong anthropogenic pressure.

In the urban environment, over time one can expect a special life form (synanthropic birds) with a complex of new morphological and functional and behavioral adaptations to emerge. The ecological niches of each synanthropic species will be represented by its functional role in the community, for example, by its trophic status. D. V. Vladishevsky [8] proposes to introduce a term “trophic convergence” the main idea of which is feeding of several bird species on similar food. In natural conditions, the species after the nesting period that abounds in food (mainly various invertebrates) switch to feed on specific types of food like berries, seeds and others. Meanwhile, in anthropogenic ecosystems single-type food is present all year round. Several authors [12] confirm the emergence of typical feeding behavior, including longer duration of the feeding period, feeding rhythm, and other traits. At the same time, ecological niches of distantly related taxa can strongly converge, for example, dove and jackdaw feeding on dumps; they are of different systematic groups, but their trophic niche is the same.

As a result, we agree with the statement that the formation of urban populations occurs through non-hereditary behavior changes and the adaptations take place not at the level of individuals but at the level of population structure. However, in the long term, the pressure of natural selection under new environmental conditions must lead to evolutionary changes which are inheritable. But there are no facts confirming this statement yet.

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