

URBANISATION, ADAPTATION PROCESS OF BIRDS POPULATIONS TO URBAN ENVIRONMENT

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Abstract. This paper reflects the degree of bird urbanization evolution on the example of Chișinău city. 93 recorded species on the territory of the city were classified into the following synanthropic groups: mandatory – 9 species, facultative – 53 species, provisional – 21 species, and 9 species of birds were neutral. The largest group is the facultative one with 53 species, which shows that urban areas provide favourable conditions similar to natural environment to the species with a high degree of plasticity and allow them to find favourable conditions for breeding and feeding in city parks and squares. The urban ecosystem is not to be neglected from ornithological point of view.

Keywords: ornitofauna, synanthropic species, urban environment.

Rezumat. Urbanizarea, proces de adaptare al populațiilor de păsări la mediul urban. Lucrarea de față reflectă gradul de evoluție a urbanizării speciilor de păsări pe exemplul orașului Chișinău. Cele 93 de specii inventariate pe teritoriul orașului au fost clasificate în următoarele grupe sinantropice: obligatorii – 9 specii, facultative – 53 specii, provizorii – 21 specii și neutre – 9 specii de păsări. Cea mai numeroasă este grupa facultativă cu 53 specii. Aceasta denotă că mediul urban oferă condiții favorabile asemănătoare cu mediul natural speciilor cu un grad înalt de plasticitate și le dă posibilitatea să găsească condiții prielnice pentru reproducere și hrană în parcurile și scuarle din oraș. Ecosistemul urban nu este de neglijat din punct de vedere ornitologic.

Cuvinte cheie: ornitofaună, specii sinantropice, mediul urban.

INTRODUCTION

The current state of animal world diversity, particularly the bird population is determined by natural and anthropogenic ecosystem functioning. The reduction of the number and surface of natural ecosystems is caused by both their use in agriculture and the increase of the territories of the localities. In this case, the city becomes a factor and a source of intensification of synurbanisation process – a new term created by ecologists (ANDRZEJEWSKI et al., 1978; BABINSKI-WERK et al., 1979; cited by LUNIAK et al., 2004). This indicates an adaptation of animal populations to urban conditions, which are related to the normal existence of animals in their natural environment, including the reproduction.

Synurbanisation is connected to two other terms: synanthropization and urbanization. Synanthropization relates generally to animal populations adaptation to the conditions created by humans, while urbanization refers to the changes within environment caused by urban development. Therefore, ecologists consider synurbanisation as the particular case of the synanthropization under specific conditions of urbanization. The interest regarding synurbanisation phenomenon is growing, because it proves the ecological and ethological plasticity, but also micro-evolutionary changes in animal populations exposed to anthropogenic pressure. It is also a point of interest in applied ecology, as it involves the opportunity to enrich and to control wildlife within the city. The increase of birds species, represented by a growing number of local populations have established in cities, where their abundance is rising. Synurbanisation can be considered as wildlife response to the global expansion of urbanization. In terms of nature, cities would be the explosion of a new and strange environment, characterized by the highest degree of anthropogenic pressure. It is possible in the future biocoenotic oases (parks, squares, water basins) in urban areas created by humans, will become saving islands for some species.

It is clear that some species or species individuals are able to overcome environmental barriers imposed by urbanization and successfully adapt to specific conditions of new ecological niches.

Among general requirements that must be satisfied for synurbanisation there is the ecological demographic and behavioural plasticity; specific conditions that must be satisfied concern the trophic spectrum, which must be as wide as possible, and the preferred habitats (LUNIAK et al., 2004). The purpose of this paper is to elucidate the urbanization process tempo of wild birds on the example of Chișinău city.

MATERIALS AND METHODS

Studies adaptability rhythm of bird species in urban areas was conducted in Chișinău and its surroundings including forest parks, forest strips, agrocoenosis, vineyards, orchards, which at their turn form the corridor of bird species penetration within the city, thus directly contributing to the process of adaptation of some species to particular inhabiting conditions and, ultimately, to urbanization process. To elucidate the urbanization process, there were used urbanization indexes, which indicate the species belonging to exclusively urbanized environment. A unique formula for determining the urbanization does not exist, but some aspects that would allow characterizing this phenomenon can be identified. Following these ecological - faunistic investigations in Chișinău, there were found 93 species of birds

visiting the area at different times of the year (VASILAȘCU, 2007). The recorded species were classified after KLAUSNITZER (1990). For the zoogeographical analysis of urban and suburban avifauna species originating in Chișinău city, there were used the criteria established by Voous, using data from fauna of Romania (CĂTUNEANU et al., 1978).

RESULTS AND DISCUSSIONS

Fundamentally, the study of urban avifauna is determined by two basic processes: synanthropy and urbanization. Synanthropy as phenomenon appeared about 6-10 thousand years ago, with the appearance of settlements, a process described by several researchers (PETERS, 1974; POLOVNY & SUSTEK 1982 etc.), while the phenomenon of urbanization is determined by the development and expansion of cities (KLAUSNITZER, 1990).

The synurbanisation process is determined differently by researchers. Thus, BLAGOSCLONOV (1991) distinguished three groups of birds under anthropogenic influence: a) synanthropic, which accepts only the proximity to human activity; b) anthropophilous, which includes birds taking advantages of civilization effects; c) anthropophob, including birds that avoid such effects.

Another classification of bird species regarding the degree of acceptance of localities was proposed by KLAUSNITZER (1990):

- a) mandatory - species which can be found exclusively in anthropogenic biotopes throughout the year;
- b) facultative - species that found favourable conditions in the anthropogenic biotopes, but may form populations also in natural environments;
- c) provisional - species that can be met in certain periods within the cities (winters or passage);
- d) neutral - bird species whose main populations inhabit the natural environment and only a part of them can be found in anthropocoenoses.

Guided by KLAUSNITZER's classification the ecological-faunistic study of city birds have been carried out, on the example of Chișinău city. Following this study, there were triggered some interesting conclusions regarding the ecological aspect. The city has a large number of green spaces (squares and gardens), where the majority of local avifauna is concentrated, but the presence of large parks and various aquatic biotopes allow the inhabitancy of a rather rich bird population.

Mandatory species are birds that fully exploit the ecological conditions of cities: the abundance of food, shelter and protection places etc. This category in professional literature is named as synanthropic species (BLAGOSCLONOV, 1991) and completely urbanized species (ARDELEAN & BEREȘ, 2000). In Table 1 the list of bird species from mandatory group of Chișinău is given.

Table 1. Bird species from the mandatory group of Chișinău city.
Tabel 1. Speciile incluse în grupa de păsări obligatorii, din orașul Chișinău.

No.	Species	Zoogeographic origin	Phenologic type		Nesting mode
			natural	local	
1.	<i>Columba livia domestica</i>	M	-	S	F
2.	<i>Streptopelia decaocto</i>	IA	-	S	F
3.	<i>Athene noctua</i>	TM	-	S	B
4.	<i>Tyto alba</i>	C	-	S	B
5.	<i>Hirundo rustica</i>	H	-	SV	F
6.	<i>Delichon urbica</i>	PA	-	SV	F
7.	<i>Passer domesticus</i>	PA	-	S	B
8.	<i>Dendrocopos syriacus</i>	M	-	S	B
9.	<i>Galerida cristata</i>	PA	-	S	F

Legend: Zoogeographic origin: M – Mediterranean, IA – Indo-African, C – Cosmopolite, TM – Turkestan-Mediterranean, H – Holarctic, PA – Palaearctic; Nesting mode: B - burrow (cavities), F - free (open); Phenologic type: S – sedentary, SV – summer visitor.

Legendă: Originea zoogeografică: M - mediteranean, IA - indo-african, C - cosmopolit, TM - turkhestano-mediterranean, H - holarctic, PA – palearctic; Modul de cuibărire: B - scorburi, F - liber (deschis); Tipul fenologic: S - sedentar, SV - oaspete de vară.

In this category, there are includes two species of summer visitors and seven sedentary very prolific species, some of which are inconvenient for man, such as house sparrow (*Passer domesticus*), domestic pigeon (*Columba livia domestica*) already living without human care, and two species *Corvus monedula* and *C. frugilegus* became completely synanthropic.

Facultative species are present for long time in the city fauna, but they can also form populations in natural environment, which are ecologically different from each other. They nest mostly in gardens with tree vegetation (trees and shrubs). These species are called anthropophilous after LUNIAK et al., (1990). However, ARDELEAN & BEREȘ, (2000) called this group as conditionally urbanized, because the bird species introduced in this group requires special conditions, such as old stand, trees with hollows, the presence of water, abundant hydrophilous vegetation.

This is the case of *Sylvia curruca* that has certain requirements to vegetation; it prefers coniferous shrubs to install the nest and tall trees with well-developed crown where it finds food. In this group, we also find some large differences in terms of geographical populations among species; for example, *Turdus merula*, which was a characteristic species for forests, began to settle in urban parks in Germany since the first decades of the 19th century (LUNIAK et al., 1990). The species continued its expansion, so at the beginning of 20th century it reached western

Poland. For some time, the northern limit of spread of urban populations of this species includes Oslo, Helsinki, St. Petersburg, Kiev. Blackbird urban populations have not yet occupied the north-eastern limit of the species area, as it is still absent in Moscow, even though the blackbird is a common species in the region. However, the speed and limit spread of urban populations of blackbird are comparable with the most intensive zoogeographical expansion of birds, such as *Streptopelia decaocto* in Europe, *Passer domesticus* and *Sturnus vulgaris* in North America. In all known cases, the installing of the blackbird in cities has been initiated by individuals that spent the winter in urban environment and remained there for the breeding season. Usually, the blackbird first occupies the large cities (LUNIAČ et al., 1990) and then the smaller ones. In Moldova, the phenomenon of urbanization of the species *T. merula* occurs slowly, there was not registered the expansion of the species within the city, although it is a common species often seen in winter, for example in the winter of 2009-2010 in the Botanical Garden and in a square near a housing block there were eight individuals. There were also found differences concerning the distance of approaching to man in urban areas (Botanical Garden – 1.5-3 m distance) and natural (forest from Trebujeni – 10-15 m). Perhaps in the future that species will become common for Chișinău bird population along with other species such as *Turdus philomelos*, *Carduelis carduelis*, *Phoenicurus ochruros*, *Coccothraustes coccothraustes* that will contribute to the increase of urban avifauna diversity.

This phenomenon is also found in the mallard (*Anas platyrhynchos*). In London, it nests in flower pots on rooftops (FITTER, 1949). In our country, this species has become common and numerous during the breeding season, as well as during the migration period, the distance of approaching to man decreased significantly (from 1.5 to 3 m).

In urban areas many populations of birds are more tolerant to human presence, thus more easily defeating the ecological-psychological barrier, what is necessary to their establishing localities, inclusive cities. In Chișinău, there were registered 53 bird species belonging to the facultative group (Table 2).

Table 2. Bird species from the facultative group of Chișinău city.
Tabel 2. Speciile de păsări ce aparțin categoriei facultative, din orașul Chișinău.

No.	Species	Zoogeographic origin	Phenologic type		Nesting mode
			natural	local	
1.	<i>Ixobrychus minutus</i>	OW	SV	SV	F
2.	<i>Anas platyrhynchos</i>	H	PM	PM	F
3.	<i>Gallinula chloropus</i>	C	PM	SV	F
4.	<i>Fulica atra</i>	PA	SV	SV	F
5.	<i>Columba palumbus</i>	ET	SV	SV	F
6.	<i>Streptopelia turtur</i>	ET	S	S	F
7.	<i>Cuculus canorus</i>	PA	SV	SV	F
8.	<i>Asio otus</i>	H	S	S	B
9.	<i>Strix aluco</i>	PA	S	S	B
10.	<i>Apus apus</i>	PA	SV	SV	B
11.	<i>Alcedo atthis</i>	LV	SV	SV	B
12.	<i>Picus canus</i>	PA	S	S	B
13.	<i>Dendrocopos major</i>	PA	S	S	B
14.	<i>Dendrocopos syriacus</i>	M	S	S	B
15.	<i>Dendrocopos medius</i>	EU	S	P	B
16.	<i>Dendrocopos minor</i>	PA	S	S	B
17.	<i>Jynx torquilla</i>	PA	SV	SV	B
18.	<i>Phasianus colchicus</i>	CH	S	S	F
19.	<i>Motacilla alba</i>	PA	SV	SV	B
20.	<i>Oriolus oriolus</i>	EU	SV	SV	F
21.	<i>Sturnus vulgaris</i>	ET	PM	SV	B
22.	<i>Garrulus glandarius</i>	PA	S	S	F
23.	<i>Pica pica</i>	PA	S	S	F
24.	<i>Corvus monedula</i>	PA	S	S	B
25.	<i>Corvus frugilegus</i>	PA	S	S	F
26.	<i>Corvus corone cornix</i>	PA	S	S	F
27.	<i>Acrocephalus arundinaceus</i>	ET	SV	SV	F
28.	<i>Sylvia curruca</i>	ET	SV	SV	F
29.	<i>Sylvia atricapilla</i>	EU	SV	SV	F
30.	<i>Sylvia borin</i>	EU	SV	SV	F
31.	<i>Remiz pendulinus</i>	PA	SV	SV	F
32.	<i>Phylloscopus collybita</i>	PA	SV	SV	B
33.	<i>Hippolais icterina</i>	EU	SV	SV	F
34.	<i>Ficedula albicollis</i>	EU	SV	SV	B
35.	<i>Muscicapa striata</i>	ET	SV	SV	B
36.	<i>Saxicola rubetra</i>	EU	SV	SV	F
37.	<i>Phoenicurus phoenicurus</i>	EU	SV	SV	F
38.	<i>Phoenicurus ochruros</i>	PX	SV	SV	B
39.	<i>Erithacus rubecula</i>	EU	PM	PM	F
40.	<i>Luscinia luscinia</i>	PA	SV	SV	F
41.	<i>Sitta europea</i>	PA	S	S	B
42.	<i>Certhia familiaris</i>	H	S	S	B
43.	<i>Turdus merula</i>	EU	PM	PM	F
44.	<i>Turdus philomelos</i>	EU	PM	PM	F

45.	<i>Parus palustris</i>	PA	S	S	B
46.	<i>Parus major</i>	PA	S	S	B
47.	<i>Parus caeruleus</i>	PA	S	S	B
48.	<i>Passer montanus</i>	PA	S	S	B
49.	<i>Fringilla coelebs</i>	EU	PM	PM	F
50.	<i>Coccothraustes coccothraustes</i>	PA	S	S	F
51.	<i>Carduelis chloris</i>	ET	S	S	F
52.	<i>Carduelis carduelis</i>	ET	S	S	F
53.	<i>Serinus serinus</i>	M	SV	P	F

Legend: Zoogeographic origin: TM – Turkestan-Mediterranean, H – Holarctic, PA – Palaearctic, PX – Paleoxeric, ET – European-Turkestan, EU – European, M – Mediterranean, OW – old world, CH – Chinese; Nesting mode: B – burrow (cavities of anthropogenic origin), F – free (open); Phenologic type: S – sedentary, SV – summer visitor, PM – partial migratory, P – passage.

Legendă: Originea zoogeografică: TM – turkhestano-mediteraneană, H – holarctic, PA – palearctic, PX – paleoxeric, ET – europeo-turkestan, EU – european, M – mediteranean, OW – Lumea Veche, CH – Chineză; Modul de cuibărire: B – scorburi (cavități de natură antropogenă), F – liber (deschis); Tipul fenologic: S – sedentar, SV – oaspete de vară, MP – migrator-parțial, P – pasaj.

Provisional species belong to anthropophylous species that at certain year seasons use the trophic potential of the cities, they also include some bird species – winter visitors and passage species that spent the cold season in our zone. It also includes birds from suburbs with orchards or agricultural land embedded in localities. The species of this group are included in Table 3.

Table 3. Bird species from the provisory group of Chișinău city.
Tabel 3. Speciile de păsări ce aparțin categoriei provizorii, din orașul Chișinău.

No.	Species	Zoogeographic origin	Phenologic type		Nesting mode
			natural	local	
1.	<i>Accipiter nissus</i>	PA	S	WV	-
2.	<i>Accipiter gentilis</i>	H	SV	P	F
3.	<i>Buteo buteo</i>	H	SV	P	F
4.	<i>Falco tinnunculus</i>	OW	PM	PM	F
5.	<i>Falco subbuteo</i>	PA	S	P	F
6.	<i>Larus argentatus</i>	HA	PM	P	F
7.	<i>Larus ridibundus</i>	PA	PM	P	F
8.	<i>Motacilla flava</i>	PA	SV	P	F
9.	<i>Lanius collurio</i>	PA	SV	P	F
10.	<i>Bombycilla garrulus</i>	PA	WV	WV	-
11.	<i>Troglodytes troglodytes</i>	H	S	S	F
12.	<i>Regulus regulus</i>	H	WV	WV	-
13.	<i>Carduelis cannabina</i>	ET	S	SV	F
14.	<i>Carduelis spinus</i>	PA	WV	WV	-
15.	<i>Carduelis flammea</i>	ET	WV	WV	-
16.	<i>Phylloscopus sibilatrix</i>	PA	SV	P	F
17.	<i>Phylloscopus trochilus</i>	PA	SV	P	F
18.	<i>Turdus pilaris</i>	EU	PM	PM	F
19.	<i>Parus ater</i>	PA	WV	WV	-
20.	<i>Aegithalus caudatus</i>	PA	S	P	-
21.	<i>Pyrrhula pyrrhula</i>	PA	WV	WV	-

Legend: Zoogeographic origin: H – Holarctic, PA – Palaearctic, EU – European, ET – European-Turkestan, OW – old world, CH – Chinese; Nesting mode: F – free (open); Phenologic type: S – sedentary, SV – summer visitor, WV – winter visitors, PM – partial migratory, P – passage.

Legendă: Originea zoogeografică: TM – turkhestano-mediteraneană, H – holarctic, PA – palearctic, PX – paleoxeric, ET – europeo-turkestan, EU – european, M – mediteranean, OW – Lumea Veche, CH – Chineză; Modul de cuibărire: F – liber (deschis); Tipul fenologic: S – sedentar, SV – oaspete de vară, WV – oaspete de iarnă, PM – migrator-parțial, P – pasaj.

Neutral species. This group refers to the bird species observed on the city territory, but which are invasive or incidental. The species from this group are included in Table 4.

Table 4. Bird species from the neutral group of Chișinău city.
Tabel 4. Specii de păsări ce aparțin categoriei neutre, din orașul Chișinău.

No.	Species	Zoogeographic origin	Phenologic type	
			natural	local
1.	<i>Loxia recurvirostra</i>	PA	In	In
2.	<i>Carduelis flammaea</i>	PA	WV	Ic
3.	<i>Rallus aquaticus</i>	PA	P	P
4.	<i>Upupa epops</i>	LV	SV	SV
5.	<i>Nucifraga caryocactes</i>	PA	In	In
6.	<i>Turdus viscivorus</i>	ET	P	P
7.	<i>Crex crex</i>	EU	SV	SV
8.	<i>Ardea cinerea</i>	PA	SV	P
9.	<i>Motacilla cinerea</i>	PA	WV	Ic

Legend: Zoogeographic origin: H – Holarctic, PA – Palaearctic, EU – European, ET – European-Turkestan, OW – old world; Phenologic type: S – sedentary, SV – summer visitor, WV – winter visitors, P – passage, In – invasive, Ic – incidental.

From the data presented in Fig. 1 it can be seen that most of the bird species belong to the facultative group (53.57%), which reveal that urban environment provides favourable conditions similar to the natural ones of the species with high ecological plasticity and offers them the possibility to find appropriate conditions for breeding and feeding in city parks and squares.

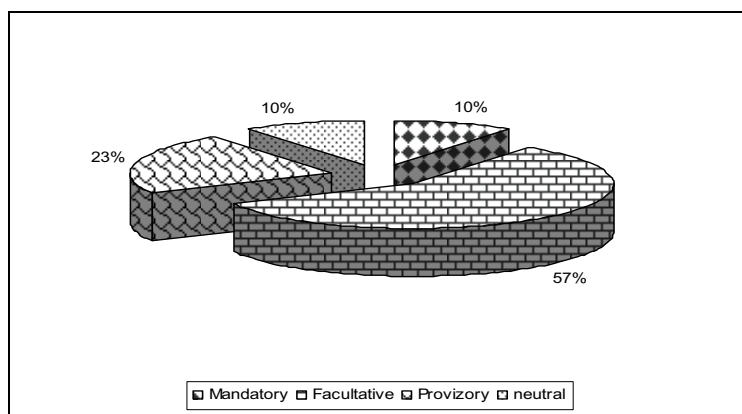


Figure 1. Numerical distribution of bird species among synanthropic groups.
Figure 1. Repartiția numerică a speciilor de păsări conform grupelor sinantropice.

Changes in environmental conditions and the architecture of city buildings has led to the disappearance of ecological niches of frequent bird species, and now some of them as *Corvus monedula*, *Athene noctua*, *Tyto alba*, *Strix aluco* withdrew to the city suburbs, while other species like *Galerida cristata*, *Perdix perdix* completely left this environment.

Corvus monedula is a synanthropic species. According to USPENSCHI et al. (1981), this species was largely met in localities and rarely in hollows in the woods. The species was common due to the presence of houses with large chimneys where it used to breed. But along with the city gasification and change of chimney shape, the species retreat to the suburbs of the city, changing its nesting preferences. Now they make their nests on high voltage poles in agrocoenosis. The same preference to build their nests on the high voltage poles of agrocoenosis was recently observed at the species *Corvus corax*, phenomenon reported in Poland (BEDNORZ, 2000), Russia (KONSTANTINOV, 1989 cited by BEDNORZ, 2000), England (RATCLIFE, 1997, cited by BEDNORZ, 2000).

Athene noctua, *Tyto alba*, *Strix aluco* according to existent data (GANEA & ZUBKOV, 1975) were rather frequent and were breeding in the attics of buildings with one or two floors in different sectors of the city, including the centre. Today these species reduced their number because the nesting places are less available.

In the last decades it can be seen that as humans change the natural landscape disturbing the normal operation of the vital process of animals, more species of birds find refuge in urban areas. In this context, we mention the positive role of the city in maintaining species diversity of birds, also here we mention about the change of nest location, observations recorded in some species of the fauna of Chișinău and its suburbs. For example, the species *Phoenicurus ochruros*, whose process of adapting to urban conditions occurs quickly. A few decades ago, this species could be found only on rocky shores of the Nistru River in the north of the republic, currently it is a common species both in the yards as well as in the tall buildings, parks, squares of the city. Probably the construction elements remind them of rocky sites.

The presence of tall buildings in the city attracted other species that prefer them, such as *Apus apus*, *Delichon urbica*, *Columba livia domestica* etc. These species build their nests in cracks between the blocks of residential buildings. The atypical distribution of nests was found in *Passer domesticus*, which places its nests in public lighting lampshades poles and inside semaphores' poles. *Sturnus vulgaris* build its nests in holes located over three meters height inside concrete poles of lighting city net. *Parus major* places its nests inside pipes that serve as housing for the vineyards near apartment buildings. IANKOV (2005) cited a particular case of this species nesting: in the Sofia city zoo at the end of 1940's a nest was found placed in a hole in a lion cage.

Another species, *Fringilla coelebs*, being a typical forest species, entered the urban area and becomes frequent. Adaptation to the urban conditions indicates the high plasticity of the species, which is in process of synanthropization. Making comparison between the species density of forest ecosystem in Codri area (74.00 pairs/km²) (MUNTEANU & ZUBCOV 2005) with the urban (10.27 pairs/km²), there is noted a significant difference, but still the species density in city is higher than that of other birds.

Hirundo rustica, until recently was not recorded in the city (AVERIN & GANEA, 1970), but at present, it can be seen quite often. This fact is due to the appearance of goats and cows in the city suburbs, which has contributed to the spreading of dung fly, a source of food for this species. Its nests are usually located at the windows of buildings, also the species nests on roof beams and even on those of commercial halls in downtown; it was found in abandoned buildings on the park territory where aquatic biotopes are present.

Change of the architecture of the houses in the late 1990's in rural localities has led to the expansion of *Delichon urbica* species in these habitats.

Columba palumbus, according to existent data (USPENSII, 1981) was a rare species, but in the last years its number increased significantly, the species being noticed in urban forest parks of Chișinău, where it often breeds.

CONCLUSIONS

From the above-mentioned information, we can conclude that the urban ecosystem is not to be neglected from ornithological point of view. According to the classification of bird species after the degree of acceptance of localities the following groups were emphasized: mandatory - 9 species, facultative - 53 species, provisional - 21 species, neutral - 9 species of birds.

The largest group is the optional one with 53 species, which shows that urban areas provide favourable conditions similar to the natural environment of the species with a high degree of plasticity and allow them to find favourable conditions for breeding and feeding in city parks and squares.

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