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Floristic diversity in selected city parks in southern Poland

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Abstract
Ecosystems of city parks are one of the most important refuges of biodiversity in urbanized areas. Recently, naturalists have had an increased interest in floristic diversity in regions that have been drastically modified by human activity, particularly in urban spaces. Investigations were conducted at various levels of the biological organization, to protect the environment and to promote floristic diversity. The aim of this study is to present floristic diversity in urban parks in southern Poland. The research was conducted in 10 parks located in 3 cities (Dąbrowa Górnicza, Sosnowiec and Będzin). These parks have been formed at different times, on various parent rocks. They are both natural and anthropogenic in origin and have different sizes (the smallest being 6 ha and the largest 67 ha). Their common features are way of use and management. The results of this investigation have confirmed 426 vascular plants belonging to 83 families and 247 genera. The highest number of species belongs to Asteraceae and Poaceae. Grabek Park is the most species rich (288) in comparison to the other parks investigated. Research on urban parks shows important links between floral diversity and biodiversity within highly urbanized areas in city centres and in urban spaces in general. This variety includes both native species and alien species, which are often called 'park species' with a decorative origin.

1. INTRODUCTION

Parks are an important element of green areas of cities and serve various purposes such as recreation, health and social functions and improving the condition of the urban environment [Breuste et al. 2013]. In general, their biocenotic function is ignored. Some parts of parks are fragments of transformed natural communities, such as forested or artificially planted areas, and nowadays are completely altered.

The developing processes of urbanization are usually accompanied by undesirable environmental and social problems, consisting mainly of drastic loss of natural habitat and its fragmentation, leading to deterioration of the environment in the form of reduction of green areas [Pukowiec-Kurda 2018] and straightening of rivers in cities and surrounding areas [Grimm et al. 2008]. Such action may lead not only to loss of biodiversity and disintegration of ecological systems [Haines-Young, Potschin 2010; Banaszek et al. 2014; 2017], but also to a reduction in the social value of urban areas. Urban green space refers to public spaces in city areas, mostly covered by different types of vegetation, which include urban parks, woodlands, street trees, square plantings and others social infrastructures. City parks are often designed along the river in many cities which also influences species composition and biodiversity. They are also elements of ecological network [Izakovičová, Świąder 2017].

The advantages of urban green areas are notable primarily in city parks, where valuable urban biotopes generate a varied set of substantial ecosystem services for people [Niemelä et al. 2010; Konijnendijk et al. 2013].

The concept of ecosystem services is defined as the benefits that people derive, directly or indirectly, from ecosystems and can be classified into provisional, regulating, cultural and supporting services in accordance with the Millennium Ecosystem Assessment [MEA 2005]. Biological diversity has been shown to play a key role at all levels of the ecosystem services hierarchy [Mace et al. 2012]. Efforts to mitigate global biodiversity loss have traditionally concerned large, biodiverse and relatively untouched natural habitats and ecosystems [Lovell, Johnston 2009; Cornelis, Hermy 2004; Rahmonov et al. 2013]. High biodiversity has also been observed in urban areas in urban parks or city parks. City parks are a specific ecological system in urban areas and are most often considered as green spaces for recreational purposes. They are defined as delineated open space areas, mostly dominated by vegetation and water, and are generally meant for public use. City parks are usually large, but many smaller 'pocket parks' also exist. City parks are usually locally defined (by authorities) as 'parks' [Konijnendijk et al. 2013].

Today, city parks are often created in areas changed by human activity and on artificially (anthropogenically) created grounds composed of rocks of diverse origin, from various geological periods, and characterized by diverse chemical compositions [Pukowiec-Kurda et al. 2019]. Such grounds and soils differ in their physical, chemical and water-retaining properties. Such conditions are the reasons that the formation of mosaic or micro-mosaic habitats and new ecological niches for various species with diverse ecological requirement can take place, from algae to flowers [Czaja et al. 2014; Rahmonov et al. 2016]. This is one of the most important causes of biodiversity in anthropogenic areas, including urban parks [Sikorski et al. 2012]. In contrast, parks created in natural ecosystems feature fewer plant species, due to their stability and a lesser degree of human interference. Urban parks, as one specific type of urban green space, constitute particularly important biodiversity hotspots in the cityscape [Nielsen et al. 2013].

The aim of this study is to present the ecological and floristic diversity of urban parks within the highly industrialized region of southern Poland, the former Upper Silesian Industrial District.

2. MATERIALS AND METHODS

Studies on the composition of vascular plants were carried out in the years 2014–2019. The floristic material was collected in four cities in southern Poland (Fig. 1) in Silesian Voivodeship. Ten parks were chosen for investigation during this study: Grabek, Jordana (Czeladź), Hallera, Zielona, Sielecki (Dąbrowa Górnicza), Środula, Leśny (Sosnowiec), Góra Zamkowa, Syberka Niska and Park Wojkowice (Będzin). These parks have been formed at different times, on various parent rocks, both natural and anthropogenic transported ground [Rahmonov et al. 2018], have different size surfaces and fulfil the same function as outlined in table 1.

The collected floristic materials (both native and alien plant species) were analysed in terms of life form, botanical family, geographical–historical groups and phytosociological affiliation of species. Classification of species with regard to their affiliation to geographical–historical groups [Kornaś 1968] and names of flowering plants and pteridophyte species were given by Mirek et al. [2002]. Urban parks flora was analysed in terms of the share of Raunkiaer's life forms, ecological indicator values and phytosociological affiliation by following the works of Zarzycki et al. [2002], Rutkowski [2011] and Matuszkiewicz [2004].

3. STATISTICAL ANALYSES

The collected data were also subjected to statistical tests aimed to show whether there are statistically significant differences in the floristic composition in terms of geographical–historical groups of flora and life forms. First, the analysed parks were compared in terms of differences in the ratio of species representing a given geographical–historical group of flora using the chi-squared test (χ^2), the significance level equal to $\alpha = 0.05$. All sites were compared together, then with each other. Similarly, the parks were compared with each other in terms of the occurrence of individual life forms of plants. These tests were performed using the PAST 3.0 software [Hammer et al. 2001].

4. RESULTS

4.1. Taxonomical diversity

The results of floristic research on vascular plants in the urban parks have confirmed the occurrences of 426 plants. The most numbers of species are represented by parks Grabek (288), Sielecki (252) and Góra Zamkowa (249), while the least number of species was found in the park of Zielona (153), where human activity is the lowest (Fig. 2). The confirmed species belonged to 83 families and 247 genera. The vast majority of taxa are represented by the following botanical families: Asteraceae (30), Poaceae (24), Rosaceae (15), Fabaceae (12), Caryophyllaceae (10), Brassicaceae (11), Apiaceae (10), Lamiaceae (9) and Pinaceae (6). The most species are represented by the genera *Aster* and *Poa*.

Species diversity in the area of individual parks is different. This is mainly connected with the management and functioning of park city. Park Zielona fulfils an ecological and biocenotic role, and its species composition is related to natural ecosystems. It is not allowed to interfere (introduction of alien species) in the ecosystem because it is protected by law as ecological land. Hence, it has a small number of species in comparison with the other analysed parks. City parks like Środula, Syberka and Hallera are relatively young and serve mainly sports and recreational functions. For this reason, vegetation and soil cover are often transformed and indirectly affect species composition. This is also confirmed by a significant number of therophytes.

4.2. Phytosociological diversity

In the area of the 10 analysed parks, the share of species representing 66 phytosociological units at different levels was found (Table 2). Within the analysed flora, characteristic species for particular syntaxonomic groups were distinguished, including 7.33% species belonging to classes (32 species), 5.52% to orders (24), 7.13% to unions (30) and 6.21% to associations (27). It was found that 193 species (44.39% from the total number of species) were characteristic of more than one syntaxon. Lack of data or cultivated taxon is 29.44% of flora (128 species). These species have no phytosociological affiliation. They are often species with wide ecological tolerances and are

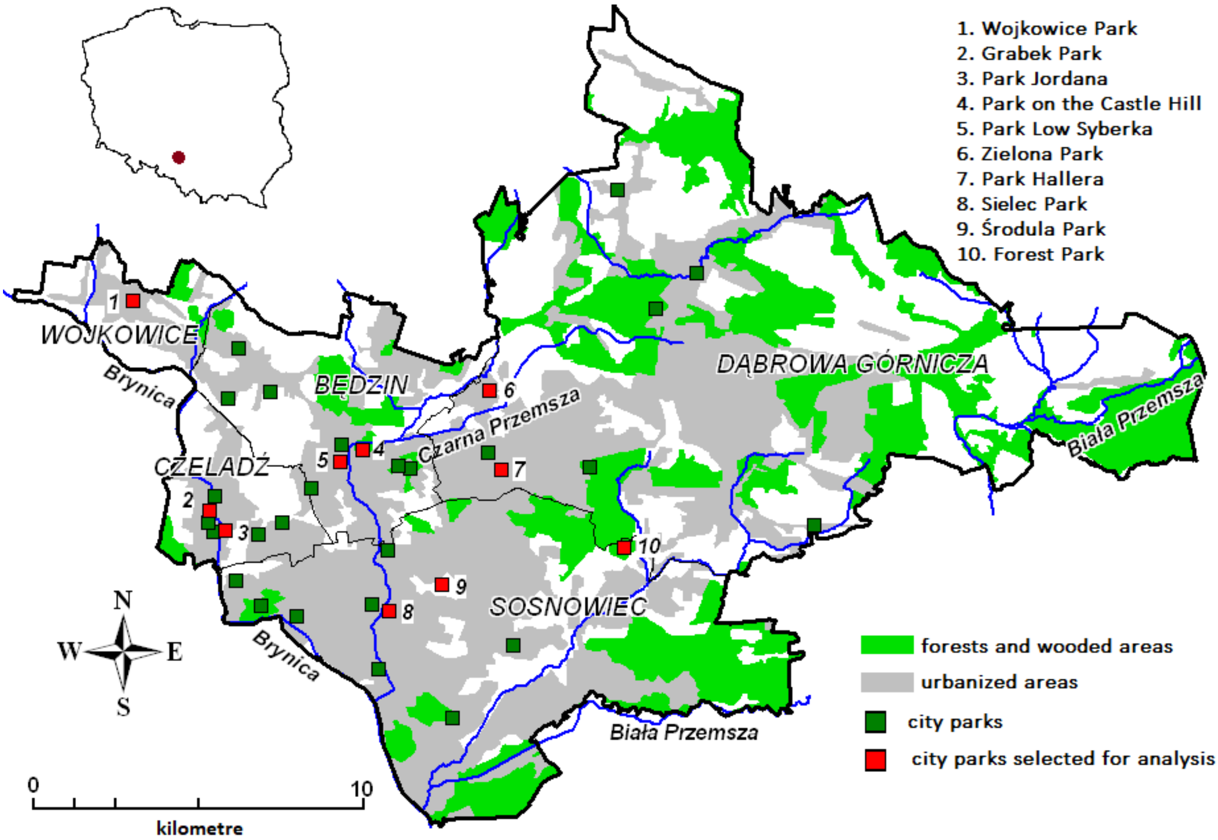
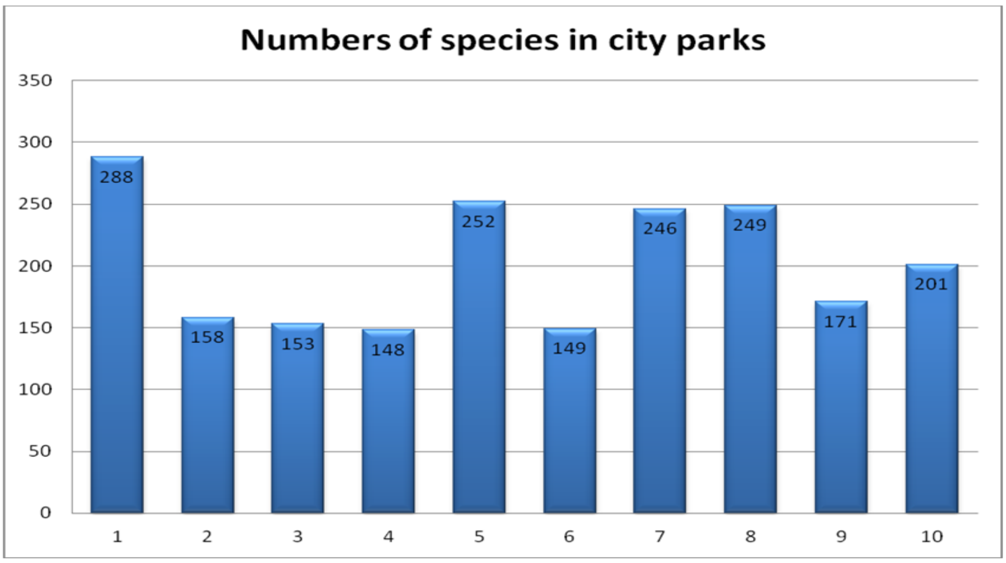


Figure 1. Location of the analysed parks in the area of Dąbrowa Coal Basin (Zagłębie Dąbrowskie)



Numbers of parks: I- Park Grabek Czeladź; II – Park Jordana; III – Park Hallera; IV - Park Zielona Dąbrowa Górnicza; V- Park Sielecki Sosnowiec; VI - Park Środula Sosnowiec; VII - Park Leśny Sosnowiec, VIII - Park Góra Zamkowa Będzin; IX - Park Syberka Niska Będzin; X - Park Wojkowice

Figure 2. Number of species in the analysed city parks (original data): 1 – Park Grabek Czeladź; 2 – Park Jordana; 3 – Park Hallera; 4 – Park Zielona Dąbrowa Górnicza; 5 – Park Sielecki Sosnowiec; 6 – Park Środula Sosnowiec; 7 – Park Leśny Sosnowiec; 8 – Park Castle Hill Będzin; 9 – Park Syberka Niska Będzin; 10 – Park Wojkowice

Table 1. Main features of selected parks

No.	Name of park	Year of establishment	Area (ha)	Main function	Type of soil	Geographical coordinates
1.	Wojkowice Park	No data	21.00	Ecological, sport and recreation	Haplic Cambisol, Technic Anthrosol	50°22'05 "N 19°02'05"E
2.	Park Grabek	No data	7.00	Ecological, sport and recreation, culture and entertainment, stroll function, economic	Technic Regosol, Technic Anthrosol	50°18'43"N 19°03'58"E
3.	Park Jordana	No data	13.20	Ecological, sport and recreation	Hortic Anthrosol, Technic Anthrosol	50°18'18"N 19°04'25"E
4.	Park on the Castle Hill	1801	5.56	Ecological, education	Haplic Cambisol, Brown Rendzinas	50°19'40"N 19°07'54"E
5.	Park Low Syberka	No data	10.00	Sport and recreation, culture and entertainment	Technic Anthrosol	50°19'27"N 19°07'18"E
6.	Zielona Park	1932	67.00	Ecological, sport and recreation	Fluvic Endogleic Cambisol	50°20'28"N 19°10'57"E
7.	Park Hallera	No data	40.10	Ecological, sport and recreation, economic	Technic Anthrosol	50°19'16"N 19°11'31"E
8.	Sielecki Park	1835	18.50	Ecological, sport and recreation, economic, culture and entertainment	Fluvic Cambisol, Cambisol	50°17'00"N 19°08'28"E
9.	Środula Park	1991	8.00	Sport and recreation, education, aesthetic, culture and entertainment	Hortic Anthrosol, Technic Anthrosol	50°17'28"N 19°09'56"E
10.	Leśna Park	No data	47.30	Ecological, sport and recreation, economic	Hortic Anthrosol, Technic Anthrosol	50°18'01"N 19°14'27"E

introduced (alien species) species of trees, shrubs and other herbaceous plants.

Plant associations rarely form with a typical species composition in the areas of urban parks due to continuous human interference. They formed in parks which were built in the area of a natural forest like Park Zielona and Góra Zamkowa. At present, a typical oak-hornbeam (*Tilio-Carpinetum*) forest with almost a full species composition is observed here (Table 2). Hence, there are also smaller amounts of species at the association level. Characteristic species at the level of the associations are mostly represented by ruderal and synanthropic plant communities which are influenced by human activity. These are *Sisymbrietum loeselii*, *Urtico-Malvetum neglectae*, *Berteroetum incanae*, *Echio-Melilotetum*, *Leonuro-Ballotetum nigrae*, *Lolio-Cynosuretum*, *Rudbeckio-Solidaginetum* and others.

Significant contribution of characteristic species in the level of classes was noted, which represented forest and non-forest communities. These are *Artemisietea vulgaris*, *Festuco-Brometea*, *Molinio-Arrhenatheretea*, *Stellarietea mediae*, *Querco-Fagetea*, *Rhamno-Prunetea* and others. Such species differentiation is connected with habitats mosaic (lawn, water, road, forest) in the area of urban parks.

4.3. Geographical–historical groups

Comparison of all the analysed parks at once in terms of geographical–historical groups of flora ratio using the chi-squared test (χ^2) showed that there are no statistically significant differences between them (obtained χ^2-value = 48.18, *p*-value = 0.084388, critical value $\chi^2_{0.05, df=36}$ = 50.9985). Differences only occur when comparing one park with another. While most of them do not show statistically significant differences (Table 3), in the case of some of them, the calculated χ^2-value exceeded the critical χ^2-value (depending on the given pair, the critical value is equal to $\chi^2_{0.05, df=3}$ = 7.81473 or $\chi^2_{0.05, df=4}$ = 9.48773 depending on the degrees of freedom). Parks that are particularly different from others are Park Wojkowice and Park Zielona Dąbrowa Górnicza.

Table 2. Phytosociological affiliation of species and syntaxonomical diversity within analysed parks (original data)

Group of syntaxon	Number of species in each syntaxonomic units	%
Classes		
Festuco-Brometea	8	1.84
Querco-Fagetea	6	1.38
Molinio-Arrhenatheretea, Stellarietea mediae	4*	1.84
Rhamno-Prunetea	3	0.69
Nardo-Callunetea	2	0.46
Agropyretea intermedio-repentis, Alnetea glutinosae, Isoeto-Nanojuncetea, Phragmitetea, Salicetea purpureae	1	1.15
Orders		
Arrhenatheretalia elatioris, Fagetalia sylvaticae	5	2.30
Artemisietea vulgaris	3	0.69
Centauretalia cyanii, Molinietalia caerulae, Polygono-Chenopodietalia	2	1.38
Artemisietalia vulgaris, Bidentetea tripartite, Convolvuletalia sepium, Glechometalia hederaceae, Thlaspietalia rotundifolii	1	1.15
Unions		
Berberidion	3	0.69
Alliarion, Alnenion glutinoso-incanae, Arrhenatherion elatioris, Carpinion betuli, Molinion caerulae, Polygono-Trisetion, Senecion fluviatilis	2	3.22
Aperion spicae-venti, Bidention tripartite, Calthion palustris, Geranion sanguine, Koelerion albescentis, Polygono-Chenopodion, Prunion fruticosae, Pruno-Rubion fruticosi, Rhododendro-Vaccinienion, Salicion albae, Seslerio-Festucion duriusculae, Tilio platyphyllis-Acerion pseudoplatani, Ulmenion minoris, Vicio lathyroidis-Potentillion argenteae	1	3.22
Associations		
Echio-Melilotetum, Populetum albae, Rudbeckio-Solidaginetum, Sisymbrietum loeselii, Urtico-Malvetum neglectae	2	2.30
Abietetum polonicom, Anthyllidi-Trifolietum montani, Berteroetum incanae, Brometum tectorum, Cardario drabae-Agropyretum repentis, Cerastio-Androsacetum septentrionalis, Corispermo-, Galinsogo-Setarietum, Galio-Urticenea, Hordetum marini, Lathyro-Melandrietum noctiflori, Leonuro-Ballotetum nigrae, Lolio-Cynosuretum, Origano-Brachypodietum, Sambucetum ebuli, Sieglingio-Agrostietum, Typhetum angustifoliae	1	3.91
Other syntaxons		
More than 1 syntaxon	193	44.39
Lack of data or cultivated taxon	128	29.44

*Given number is for one syntaxon and should be multiplied with the number of syntaxon in each line in the table, for example, 4*2.

Urban parks are anthropogenic ecosystems built to fulfil recreational functions, and alien species of high ornamental values are commonly found because of landscape aesthetics. Due to the desire for an aesthetically pleasing environment, the proportion of alien species in the urban parks investigated is very significant (Fig.3). They are often represented by tree (*Abies concolor*, *Ailanthus altissima*, *Pinus nigra*, *Salix alba* "Tristis") and shrub species (*Symphoricarpos albus*, *Tamarix ramosissima*). They are called anthropophytes and include archaeophytes, kenophytes, ephemerophytes and cultivated taxa [Mirek et al. 2002; Tokarska-Guzik 2005]. The diversity of alien species is associated with their introduction by humans [Kowarik et al. 2013].

Table 3. Obtained χ^2-value and *p*-value as a result of comparing the ratio of particular groups of species (geographical–historical groups of flora) in given location with each other (original data)

Parks		1 – Grabek Park	2 – Park Jordana	3 – Park Hallera	4 – Park Zielona	5 – Park Sielecki	6 – Park Środula	7 – Park Leśny	8 – Park Castle Hill	9 – Park Syberka	10 – Park Wojkowice
1	χ^2-value	-									
	p-value	-									
2	χ^2-value	6.4934	-								
	p-value	0.1652	-								
3	χ^2-value	0.84373	2.9601	-							
	p-value	0.93249	0.56453	-							
4	χ^2-value	9.6106*	5.9724	6.91	-						
	p-value	0.047524	0.11296	0.14072	-						
5	χ^2-value	9.8862*	1.9577	2.9992	11.272*	-					
	p-value	0.042389	0.74353	0.55796	0.023672	-					
6	χ^2-value	1.2101	4.0192	1.603	9.0684*	5.9031	-				
	p-value	0.87643	0.25939	0.80826	0.028395	0.20651	-				
7	χ^2-value	15.99*	2.6381	7.3582	6.9341	3.5218	10.504*	-			
	p-value	0.003033	0.45085	0.11813	0.074029	0.47458	0.014735	-			
8	χ^2-value	3.737	1.4414	1.2194	8.7631	3.103	2.835	8.0873	-		
	p-value	0.44277	0.83697	0.8749	0.067302	0.54074	0.5858	0.088434	-		
9	χ^2-value	3.6964	0.90269	1.6563	4.0152	3.0603	2.3303	3.3651	1.8082	-	
	p-value	0.44865	0.82478	0.79863	0.25983	0.54778	0.50674	0.33869	0.77099	-	
10	χ^2-value	12.287*	1.1987	5.1723	9.5539*	1.0941	6.8053	1.313	4.538	2.7063	-
	p-value	0.015342	0.75332	0.27007	0.022765	0.89521	0.07837	0.72604	0.33807	0.43915	-

Chi-squared test (χ^2) was adopted; significance level equal to $\alpha = 0.05$. *Statistically significant difference (χ^2-value > χ^2-critical value).

The flora of the analysed parks shows clear differentiation in terms of geographical and historical groups. Apophytes representing 295 species have the largest share, that is, about 70% of the total flora of the analysed parks. The contribution of geographical and historical groups of flora is shown in Figure 3.

Apophytes are species that often occur in habitats created as a result of human activity and form part of the native flora. In the areas of parks often occurring apophytes are *Achillea millefolium*, *Aegopodium podagraria*, *Arctium minus*, *A. lappa*, *Artemisia campestris*, *A. vulgaris*, *Calamagrostis epigejos*, *Campanula rapunculoides*, *C. patula*, *Chaerophyllum aromaticum*, *Chelidonium majus*, *Convolvulus arvensis*, *Galium aparine*, *Lamium maculatum*, *Lathyrus pratensis*, *Lolium perenne*, *Medicago lupulina*, *Melilotus alba*, *Plantago lanceolata*, *P. major*, *Poa annua*, *P. pratensis*, *P. trivialis*, *Ranunculus acris*, *Rosa canina*, *Rumex crispus*, *R. obtusifolius*, *Senecio jacobaea*, *S. viscosus*, *Silene nutans*, *Sonchus arvensis*, *Stellaria graminea*, *S. media*, *Tanacetum vulgare*, *Tragopogon dubius*, *Trifolium repens*, *Tussilago farfara*, *Verbascum thapsus*, *Vicia cracca* and others.

4.4. Plant life forms

Comparison of all 10 locations at once in terms of the occurrence of individual life forms of plants ratio using the chi-squared test (χ^2) showed that there are statistically significant differences between them (obtained χ^2-value = 109.07, *p*-value = 1.36E-05, critical value $\chi^2_{0.05,} df_{=54}$ = 72.1532). Differences also occur when comparing specific locations with each other (Table 4); the calculated χ^2-value exceeded the critical χ^2-value (depending on the given pair, the critical value is equal to $\chi^2_{0.05,} df_{=5}$ = 11.0705 or $\chi^2_{0.05,} df_{=6}$ = 12.5916 depending on the degrees of freedom). Parks that are particularly different from others are Park Zielona Dąbrowa Górnicza, Park Sielecki Sosnowiec, Park Środula Sosnowiec, Park Leśny Sosnowiec and Park Wojkowice.

Biological spectrum for the parks was prepared from 426 species of vascular plants. The most dominant life forms are, respectively, the hemicryptophytes with 37% (159 species), and megaphanerophytes together with nanophanerophytes constituting 29% (126 species) of

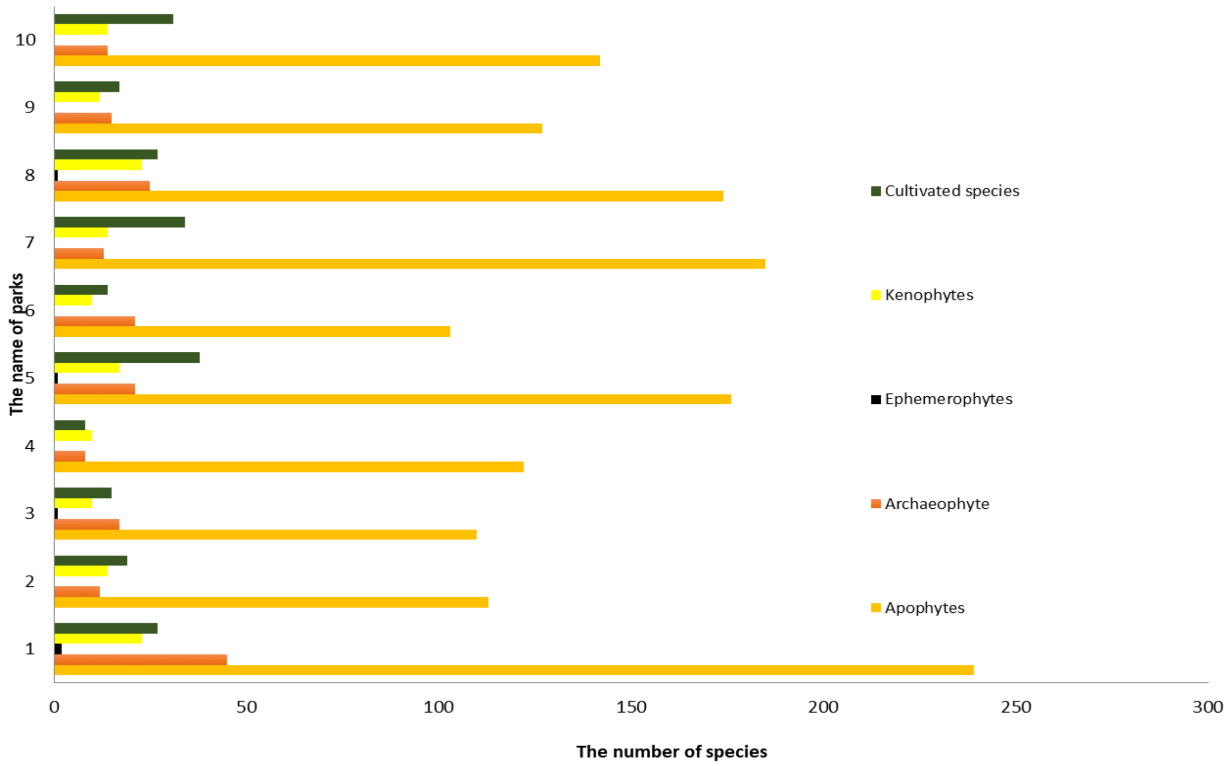


Figure 3. The number of species with geographical–historical affiliation of flora for the analysed parks (original data)

flora (Table 5). Noteworthy is the significant proportion of woody and shrubby forms.

5. DISCUSSION

The progressing anthropogenic pressure in particular climatic zones has led to or will lead to the destruction of partial natural habitats or to their complete disintegration. This is manifested by the destruction or modification of habitats, the introduction of invasive species, overexploitation, environmental pollution, climate change and agricultural and farming practices which can lead to a reduced gene pool. This contributes to the reduction and loss of biodiversity at all levels: genetic, species and ecosystem. Sources of biodiversity in majority of city parks are often connected with their management and cares. High species diversity is often related to the park habitats as river valley, urban forests and housing estates [Breuste et. al. 2013; Cornelis, Hermy 2004].
Paradoxically, despite the occurrence of most of the above-mentioned factors leading to the loss of biodiversity, the level of species diversity in urban parks is relatively high [Banaszek et. al. 2014; 2017]. Such diversity in these anthropogenic ecosystems is conditioned by many factors. This may result from the history of a given park, the reasons for its creation (e.g. parks near castles, palaces), its size, period of origin and ways of development, management or continuous modernization. Special microenvironments are created in the form of ponds or rockeries, also for plants from other climatic zones. These kinds of activities are decorative and increase the attractiveness of the park for the inhabitants of the surrounding regions even from an educational point of view. This is important, especially in areas of large polycentric agglomerations, which also include the analysed municipal parks. Modernization of the analysed parks today leads partly to the destruction and modification of habitats for the benefit of infrastructural elements.
An important ecosystem role, in terms of biodiversity, is played by the location of park establishment, the type of geological bedrock (limestone, sandstone and anthropogenic materials), the place of the park in the landscape (hill, riverside) and the features of the urban geosystem. Within the analysed parks, in several cases, the above-mentioned elements played a key role in the formation of the habitat and microhabitats. For example, the Góra Zamkowa Park was founded on a hill built of Triassic formations, and rocky outcrops are visible on the surface. The southern slopes are sunny and overgrown with xerothermic grasslands, and the semi-natural Tilio-Carpinetum forests develop on the northern slopes. The park is well decorated and subject to constant care. Such

Table 4. Obtained χ^2-value and *p*-value as a result of comparing the ratio of particular groups of species (individual life forms of plants) in given location with each other

Parks		1 – Grabek Park	2 – Park Jordana	3 – Park Hallera	4 – Park Zielona	5 – Park Sielecki	6 – Park Środula	7 – Park Leśny	8 – Park Castle Hill	9 – Park Syberka	10 – Park Wojkowice
1	χ^2-value	-									
	p-value	-									
2	χ^2-value	4.7007	-								
	p-value	0.58273	-								
3	χ^2-value	1.8746	7.9306	-							
	p-value	0.93087	0.24323	-							
4	χ^2-value	13.166*	3.9919	14.558*	-						
	p-value	0.040468	0.67777	0.023986	-						
5	χ^2-value	18.997*	5.6446	20.137*	14.872*	-					
	p-value	0.0041685	0.46416	0.0026185	0.021275	-					
6	χ^2-value	7.7392	9.9112	8.9046	12.765*	21.238*	-				
	p-value	0.25784	0.12844	0.17902	0.046918	0.0012957	-				
7	χ^2-value	19.9*	4.8303	21.828*	10.813	7.8838	18.284*	-			
	p-value	0.0028846	0.56576	0.001301	0.094317	0.24674	0.0055602	-			
8	χ^2-value	3.0886	5.3731	1.9398	10.45	17.581*	11.053	20.354*	-		
	p-value	0.79765	0.49693	0.85741	0.10695	0.0077368	0.08675	0.0023947	-		
9	χ^2-value	9.8674	6.5723	10.777	14.524*	10.763	13.517*	8.5555	9.2998	-	
	p-value	0.13035	0.36222	0.055993	0.024302	0.095977	0.035519	0.20016	0.097688	-	
10	χ^2-value	14.572*	6.5644	14.346*	16.486*	4.6768	21.043*	8.1227	11.983*	2.587	-
	p-value	0.0238576	0.36301	0.013557	0.011368	0.58588	0.0018026	0.22925	0.035017	0.76334	-

Chi-squared test (χ^2) was adopted; significance level equal to $\alpha = 0.05$. *Statistically significant difference (χ^2-value > χ^2-critical value, original data).

edaphic diversity contributes to the occurrence of taxa with different ecological requirements and in this way the flora is enriched.

In turn, parks that are located along rivers and water reservoirs have even contributed to the formation of azonal types of plant communities with incomplete species composition. These parks include Sielecki Park, Leśny (Sosnowiec) and Zielona in Dąbrowa Górnicza. Species enrichment in such conditions is often associated with transport of propagules by water from higher areas. A clear example is the migration of invasive species such as *Reynoutria japonica* occurring in all parks along the rivers flowing through them [Rahmonov et al. 2018]. Feeding birds with seeds is a potential source of emergence of new taxa, which were found several times by researchers [Tokarska-Guzik 2005].

Permanent human activity in the ecosystem of the city park leads to the formation of a variety of ecological niches on the background of mosaic habitat with a diversified surface. This does not allow the formation of typical plant communities. As a result, many species with diverse phytosociological affiliations can be found here. This situation was also found in similar objects [Dyderski et. al. 2017; Sender et al. 2016]. Many species are not bound to any plant associations.

There are species that can develop from extreme to optimal habitats. Extreme habitats in the areas of parks should be considered as soils with a high content of heavy metals [Rahmonov et al. 2019] and disturbed by trampling water–air relations in the soil cover in large surfaces. Trampling, in general, as a phenomenon has a positive effect on the formation of microhabitats and seed dispersion. Due to the above reasons, occurrence of species belonging to different phytosociological units in the park areas is justified. A significant number of species (189) is characteristic of more than one syntaxon. This clearly demonstrates the diversity of the habitat and ecological unpredictability (as during the primary succession), even when compared to the stabilizing ecological system.

In all parks, as in temperate climate, hemicryptophytes dominate in the structure of the life form. The structure of life forms of vascular flora may indicate the degree of naturalization of the vegetation of a given park. When a significant proportion of mega- and nanophanerophytes are found, it can be concluded that such a park has well-maintained greenery (a large proportion of typically park and ornamental species). The most number of megaphanerophytes, that is, 50 species, was found

Table 5. Plant life forms in urban parks in the area of Dąbrowa Coal Basin (Zagłębie Dąbrowskie, original data)

Form	1	2	3	4	5	6	7	8	9	10
	Grabek	Jordana	Hallera	Zielona	Sielecki	Środula	Leśny	Castle Hill	Syberka	Wojkowice
M	50	29	24	20	58	21	51	39	37	47
N	26	19	13	15	43	10	36	25	22	33
H	119	65	67	69	81	52	84	109	60	69
Hy	2	2	0	2	2	2	8	0	0	0
G	25	18	11	24	30	23	33	25	20	21
Ch	15	5	8	3	5	10	10	10	13	9
T	51	20	30	15	33	31	24	41	19	22
Sum	**288**	**158**	**153**	**148**	**252**	**149**	**246**	**249**	**171**	**201**

M – megaphanerophytes, N – nanophanerophytes, H – hemicryptophytes, Hy – hydrophytes, G – geophytes, Ch – chamaephytes, T – therophytes.

in the Grabek Park (Table 5). This is related to the fact that the ecosystem is heavily managed in terms of the decorativeness of the park, especially with the introduction of alien species. In turn, the least number of megaphanerophytes was found in the Zielona Park. This park was built within the natural oak-hornbeam forest, where alien species occur individually. The diversity of life forms is conditioned by the mosaic-like nature of the habitat (macro and micro landforms) and the presence of a potential biochore in the vicinity of urban parks.

6. CONCLUSION

In general, parks in the investigated region do not differ significantly in terms of geographical and historical groups. Differences in parks are visible only when comparing two specific locations, although in most cases the differences in the compared pairs are not statistically significant. According to Raunkiaer's life forms, plants are much more diverse than in terms of geographical and historical groups.

The analysed parks are important links in floral diversity within highly urbanized areas in city centres. The variety includes both native species and typical park species of ornamental or alien origin which provide ecological services for science and society. Urban parks are excellent objects for investigations and aid in the preservation of biodiversity within cities. City parks, specifically older parks, are often a point of synanthropization of many plant species from surrounding areas.

Species diversity in anthropogenic ecosystems of urban parks is observed at all levels, especially at the species and ecosystem level. The reasons for high biodiversity in these ecosystems are conditioned by both natural and anthropogenic factors resulting from the introduction of species (native and alien) and the creation of new habitats and microhabitats.

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