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FLORA OF THE CITY OF PODGORICA, MONTENEGRO – CHOROLOGIC STRUCTURE AND COMPARISON WITH THE FLORAS OF ROME, PATRAS, AND SALONIKA

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Abstract — Research on the geographical structure of the flora of Podgorica revealed that 85.9% of the species are native, while 14.1% are non-native. This ratio is typical of Mediterranean settlements, where even the most urbanized region reflects the overall character of the surrounding flora. In terms of chorologic groups, the three largest are: eury-Mediterranean (18.2%), cosmopolitan (12.6%), and steno-Mediterranean (8.3%). The percentage of endemic and subendemic plants is also significant (6.8%). Within the group of aliens, species of Asian origin prevail. Comparative analysis of the chorologic spectra of Podgorica, Rome, Patras, and Salonika revealed some similarities.

Key words: Urban flora, chorologic structure, Podgorica, Rome, Patras, Salonika, Montenegro

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INTRODUCTION

In comparison to natural environments, cities represent a relatively young habitat type. Their floras consist of a combination of both native and non-native (alien) components. Plants from surrounding natural ecosystems that can adapt to newly human-created environments are native, while species originating from geographically distant areas and introduced intentionally or unintentionally by man generally belong to the alien flora. In the geobotanical literature, all plants that become part of the flora through the direct or indirect impact of man are defined as anthropophytes. The first classification of anthropophytes was given by Thellung (1922). He distinguished two main categories based on the origin of species: apophytes, or elements of the native flora; and anthropochores, or elements of some alien flora. According to Schroeder (1969), anthropochores can be classified on the basis of three criteria: i) by their degree of naturalization (idiochorophytes, agriophytes, epecophytes, ephemerophytes, and argasiophytes); ii) by the time of immigration (idiochorophytes, archaeophytes, and neophytes); and iii) and by the manner in which man supported their immigration (idiochorophytes, acolutophytes, xenophytes, and ergasiophytes). On the other hand, Trinajstić (1975) combined three criteria (chronological, anthropological, and ecological) and distinguished four main categories: archaeophytes, paleophytes, neophytes, and neotophytes. Each of these categories are then divided into four subcategories: ergasiophytes, ergasiophygophytes, epekophytes, and ephemerophytes. Further, Trinajstić (1975) distinguished a unique category of helenopalophytes from the Adriatic Coast of Yugoslavia.

It is often very difficult to determine the exact date of introduction of a species. Archaeophytes are particularly difficult to distinguish from original species, since original and secondary areas of distribution continuously overlap. The differentiation of such taxa is further complicated by the time that has elapsed since the original introduction. Indeed, it is not always clear whether a species is native or introduced (Sykora and Westhoff, 1997).

Besides the aforementioned categories, the

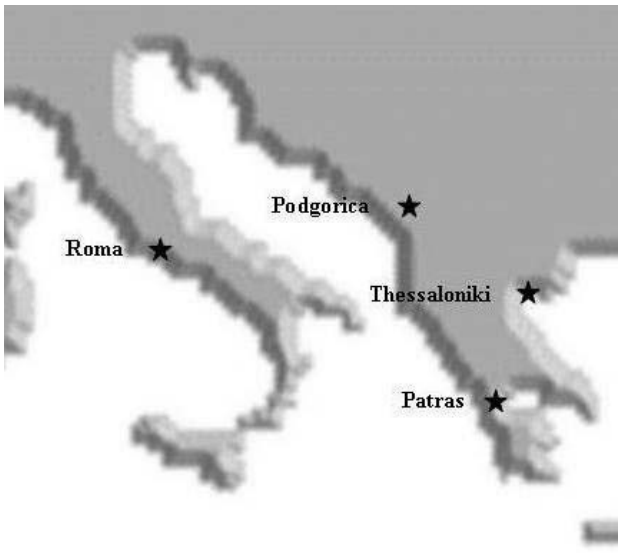

Fig. 1. Geographical locations of Patras, Podgorica, Rome, and Salonika.

urban flora also includes anekophytes or obligate weeds (Scholz, 1991). These plants have coexisted with humans since prehistoric time, which has resulted in a high level of uncertainty regarding their native ranges. This group includes: *Bromus hordeaceus*, *Capsella bursa-pastoris*, *Chenopodium album*, *Cynodon dactylion*, *Hordeum leporinum*, *Poa annua*, *Senecio vulgaris*, and *Stellaria media* (Sukopp and Scholz, 1997).

The two main objectives of this paper were: i) to present the general chorologic spectrum of the flora of Podgorica; and ii) to compare the chorologic spectra of Podgorica, Rome, Patras, and Salonika, with special reference to structure of the alien flora.

In addition, we wanted to demonstrate the importance of the native component of the flora and the inherent need to protect it by preserving remnants of both natural and seminatural habitats. Just as importantly, we call attention to alien plants and the threat they bring to diversity of the native flora.

Some general information about the selected cities is given in Table 1, while their geographical locations are shown on Fig. 1.

MATERIALS AND METHODS

The flora within the city of Podgorica currently consists of 1227 taxa (Stešević and Jovanović, 2008), four of which are excluded from our analysis: *Fraxinus excelsior*, *Asphodelus albus*, and *Myricaria germanica* (uncertain data taken from the literature); and the hybrid taxon *Carex acuta* × *elata.*

The nomenclature follows Tutin et al. (1964-1980, 1993), in some cases Greuter et al. (1984-1989).

The chorologic elements are mainly defined according to Pignatti (1982). For species which are missing, we follow Tutin et al. (1964-1980, 1993), Gajić (1980), Greuter et al. (1984-1989), and Šilić (1990). Table 2 outlines the chorologic spectrum of the flora of Podgorica with abbreviations as defined by Pignatti (1982).

Pignatti's classification system was chosen instead of the more generally accepted one of Stevanović (1992) owing to compatibility with

Table 1. General information about the cities of Patras, Podgorica, Rome, and Salonika: area, number of inhabitants, climate type, average annual temperature, and average annual rainfall.

City	Area (km^2)	No. of citizens	Climate type	Average annual temperature (°C)	Annual average rainfall (mm)
Patras	55	170,000	Typical Mediterranean	17.8	667.5
Podgorica	86	137,000	Moderate Mediterranean	15.5	1625.3
Rome	300	2,900,000	Moderate Mediterranean	15.1	839
Salonika	61	1,000,000	Typical Mediterranean	15.7	447.7

the chorologic data reported for the other three selected (sub)Mediterranean settlements: Rome (Celesti-Grapow, 1995); Patras (Chronopoulos and Christodoulakis, 1996, 2000); and Salonika (Krigas and Kokkini, 2004, 2005).

We use the term alien (sensu Richardson et al., 2000) to embrace the following related terms: naturalized, invasive, casual ephemeral, introductioned, occasional escaped plants, and cultivation relics.

In a few cases, it was necessary to harmonize the data according to Pyšek et al. (2002) due to inconsistent information about the origin of some alien taxa.

Because of the lack of information about time of introduction, structure of the alien flora is given only in respect to its origin. If a species distribution covered more than one continent, it was considered as a representative of each of them.

Similarity between the alien floras of Podgorica, Rome, Salonika, and Patras is expressed by Sørensen's index of similarity:

$$Q/S = [2\ j/(a + b)] \times 100$$

j - number of species common to both floras,

a - total number of species of the first of two floras to be compared,

b - total number of species of the second flora.

Abbreviations:

(I) - element of native (indigenous) flora

(A) - element of alien flora and

(C) - cosmopolitan element.

The general information about the compared cities presented in Table 1 was gathered from the following sources: Podgorica (Stešević and Jovanović, 2008); Rome (Celesti-Grapow, 1995); Patras (Chronopoulos and Christodoulakis, 1996); and Salonika (Krigas and Kokkini, 2004, 2005; Hellenic National Meteorological Service: www.hnms.gr).

RESULTS AND DISCUSSION

Table 2 presents the chorologic spectrum of the flora of the urban area of Podgorica. It can be seen that 85.9% of the flora are indigenous species (I),

Table 2. Chorologic spectrum of the flora of the urban area of Podgorica (classification following Pignatti, 1982).

Chorologic type/group	No. of sp.	%	Chorologic type/group	No of sp.	%
Native flora	**1051**	**85.9%**	**VII OROF. S. EURO**	**10**	**0.8**
I ENDEMIC	**83**	**6.8**	VIIa Orof S. Euro	5	0.4
Ia Endemic	53	4.3	VIIb Orof. SE. Euro	4	0.3
Ib Subendemic	30	2.5	VIIc Orof. SE. Euro-Cauc	1	0.1
II STENOMED	**101**	**8.3**	**VIII BOR**	**64**	**5.2**
III EURYMED	**233**	**18.2**	VIIIa Circumbor	33	2.6
IV MED-MONT	**21**	**1.7**	VIIIb Euro-Sib	31	2.5
V EURAS S. L.	**323**	**26.5**	VIIIc Circum Arct.-Alpin	1	0.1
Va Paleotemp	62	5.1	**IX WIDE DISTRIBUTION**	**370**	**30.3**
Vb Euras	95	7.7	IXa Pantrop	1	0.1
Vc S. Euro-S. Sib	57	4.7	IXb Med-Tur	31	2.5
Vd Euro-Cauc	49	4	IXc Paleosubtrop	3	0.2
Ve Europ	18	1.5	IXd Cosm	154	12.6
Vf C. Euro	12	1	**IXe Aliens**	**172**	**14.1**
Vg S. Euro	30	2.5			
VI ATL	**27**	**2.2**			
VIa W. Euro	6	0.5			
VIb Med-Atl	21	1.7	**TOTAL**	**1223**	**100**

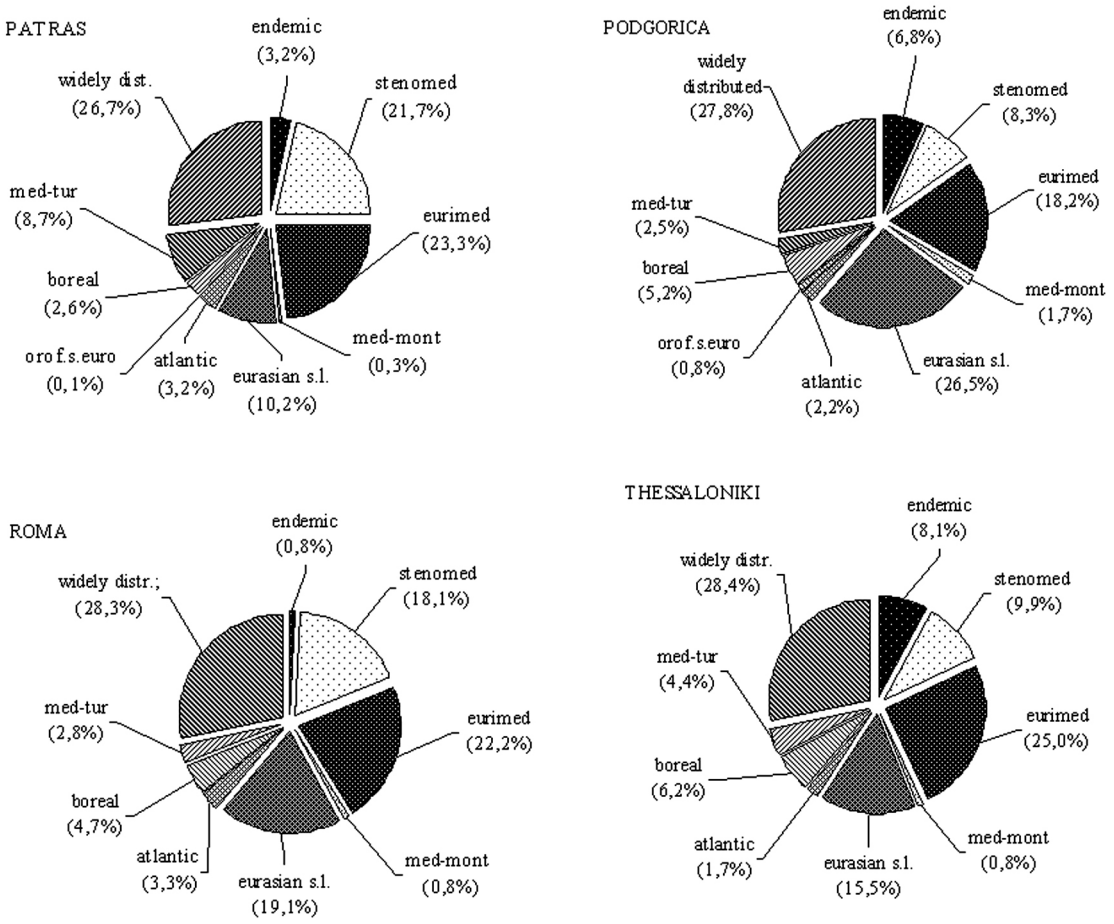

Fig. 2. Structure of the alien flora of Podgorica with respect to origin. If a species distribution covers more than one continent, it is considered as a representative of each of them.

while only 14.1% are alien species (A). Similar ratios between these two components were also presented for the floras of Rome: (I) = 84.7%, (A) = 15.3% (Celesti-Grapow, 1995), Patras: (I)= 87.6%, (A)= 12.4% (Chronopoulos & Christodoulakis, 1996 & 2000) and Thessaloniki (I)= 85.5%, (A)= 14.5%, (Krigas & Kokkini, 2004, 2005). Investigating the flora and vegetation of different Mediterranean settlements, Celesti-Grapow (1998) showed that even the most urbanized regions reflected the flora of their immediate surroundings and were rich in native species, while participation of aliens was low. Additionally, the role of apophytes was emphasized. In contrast to the Mediterranean, it has been found that Central European cities have a more uniform flora with a higher abundance of aliens, which comprise 20-60% (average 35-40%) (Brandes, 1989; Pyšek, 1998).

As for chorologic types, the widely distributed (IX: 30.3%) and Eurasian (V: 26.5%) types are prevalent, while among chorologic groups, the eury-Mediterranean (18.2%), cosmopolitan (12.6%), and steno-Mediterranean (8.3%) groups are (sub)dominant. The percentage of endemic and subendemic taxa is also significant (6.8%). The most abundant endemic taxa (4.3%) are Dinaric and Dinaric-Balkan elements of South European mountainous distribution (*Genista sericea*, *Satureja montana illyrica*, *Micromeria parviflora*, *Asperula*

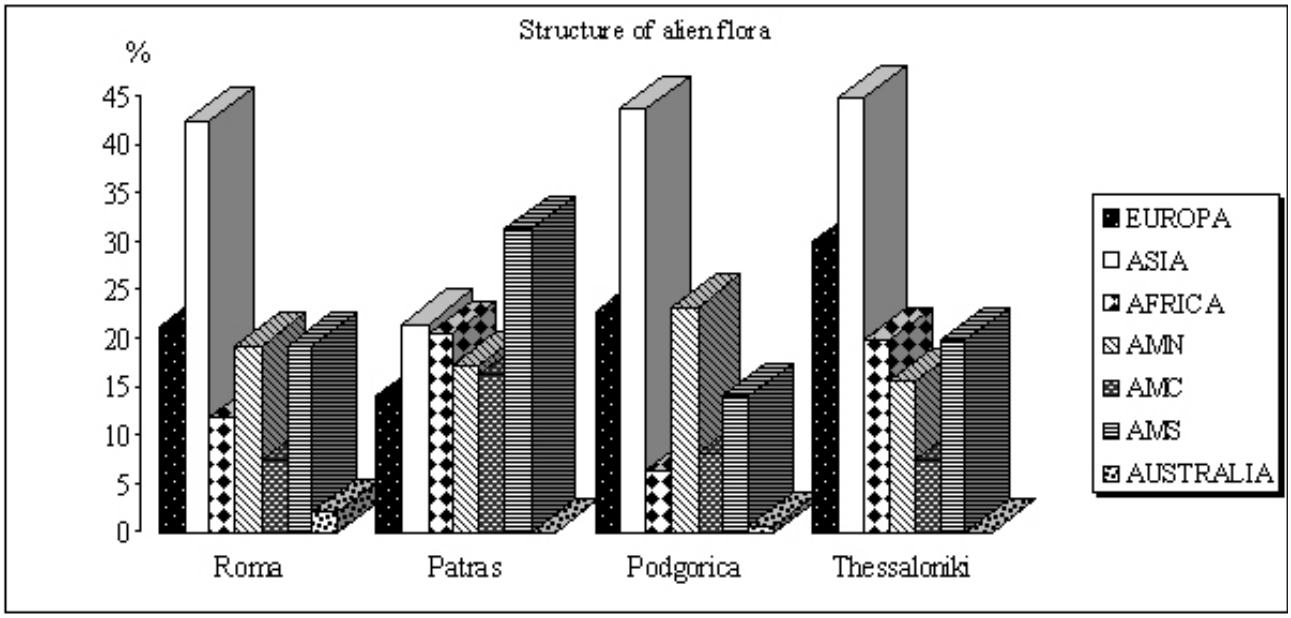

Fig. 3. Structure of the alien floras of Rome, Patras, Podgorica, and Salonika.

Table 3. Structure of the alien flora of Podgorica with respect to origin. If a species distribution covers more than one continent, it is considered as a representative of each of them.

Continent	No. of species	%
Europe	39	22.7
Asia	75	43.6
Africa	11	6.4
North America (AMN)	40	23.3
Central America (AMC)	14	8.1
South America (AMS)	24	14.0
Australia	1	0.6

Table 4. Values of the Sørensen similarity index for the alien flora of Podgorica compared to those of Rome, Patras, and Salonika.

Cities	Sørensen's Q/S index	Value (%)
Podgorica-Rome	2 × 97 * 100/(172 + 196)	52.7
Podgorica-Salonika	2 × 75 * 100/(172 + 147)	47
Podgorica-Patras	2 × 48 * 100/(172 + 93)	32.2

scutellaris, etc.), as well as Illyrian (Adriatic) and Illyrian-Balkan elements of Mediterranean distribution (*Chaerophyllum coloratum*, *Crocus dalmaticus*, *Hyacinthella dalmatica*, *Dianthus ciliatus dalmaticus*, *Hieracium waldsteinii*, *Rhamnus orbicularis*, etc.). Subendemics (2.5%) were mainly presented by Balkan-Apennine taxa (*Peucedanum coriaceum*, *Onosma echinoides*, *Bupleurum veronense*, *Matthiola fruticulosa*, etc.). Because endemic and subendemic taxa are set aside as a separate chorologic group, participation of the Mediterranean mountainous and South European orophytic groups is considerably reduced (med-mont = 1.7% and orof. s. euro = 0.8%).

Due to the abundance of natural and seminatural habitats within the city of Podgorica, numerous endemic and subendemic taxa are recorded in the central zone. However, rapid urbanization and

insufficient preservation of remaining fragments of natural habitat put serious pressure on the native flora.

The majority of endemic and subendemic species are recorded from areas near the courses of the rivers Morača and Cijevna, which are well known as floristically rich and diverse (Bulić, 1993, 1998, 2008; Bulić et al., 2008). Part of this floristic diversity is included in the flora of the city of Podgorica.

Compared with the share of endemics in the floras of Rome (0.8%), Patras (3.2%), and Salonika (8.1%), the value of 6.8% obtained for Podgorica is relatively high (Fig. 2).

Common features of the chorologic spectra of the four cities are:

1. Prevalence of elements with wide geographic distribution and approximately the same ratio of cosmpolitan (C) and alien (A) components: in Rome, (C) = 11.3%, (A) = 15.3%; in Patras, (C) = 12.8%, (A) = 12.4%; in Salonika, (C) = 12.8%, (A) = 14.5%; and in Podgorica, (C) = 12.6%, (A) = 14.1%.

2. High participation of the Mediterranean element in the broad sense (stenomed, eurimed, medmont, and med-tur): Patras (54%), Rome (44%), Salonika (39.7%), and Podgorica (30.7%).

With respect to participation of the Eurasian element in the broad sense, Podgorica surpasses the other cities by 26.5%. Within this chorologic type, the Eurasian (7.7%) and paleotemporal (5.1%) groups dominate. The South European-South Siberian group (which includes the Pontic element and the majority of its subelements) contributes 4.7% and the European-Caucasian group 4%.

In the boreal chorologic type (5.2%), the circumboreal and Euro-Siberian groups show about the same percentage (2.6 and 2.5%, respectively).

Atlantic elements participate in the spectrum with 2.2%.

The contribution of alien taxa to the chorologic spectrum of Podgorica is 14.1%, which can be considered a relatively low value. Saarisalo-Taubert (1963) pointed out the relationship between age of a settlement and structure of its flora. Following this, we consider the main reason for the small number of aliens to be an artifact of the old age of Podgorica. According to Sukopp et al. (1979), Sukopp andWerner (1983), Pyšek (1989a), and Kowarik (1990), development of a transportation system and intensive trade open better options for the introduction and spread of new species and contribute to their increasing numbers. We maintain that poorly developed trade and transportation networks are a possible second reason for the low numbers of aliens.

Other studies have demonstrated a positive correlation between the number of alien taxa and settlement size (Pyšek, 1989b, 1998; Pyšek and Pyšek, 1991; etc.). Our comparative analysis supports this assumption. Rome (300 km^2), the largest city in our study, is characterized by the highest contribution (15.3%), while Patras, the smallest city (55 km^2), has the lowest share of aliens (12.4%).

Table 3 shows structure of the alien flora in the urban area of Podgorica.

Among alien plants in the urban area of Podgorica, species of Asian and North American distribution are prevalent. In addition, the majority of taxa are considered to be escaped from cultivation. In many countries, deliberate introduction of plant species is considered to be the main road of introduction (Groves, 1998; Reinhard and White, 2001; Mack, 2003). New trends in horticulture contribute a lot. Almost as a rule biological characteristics that make species attractive for breeding contribute to their successful expansion. According to Kowarik (2003), the naturalization rate of deliberately introduced species is considerably higher than the rate of accidentally introduced ones.

For example, *Broussonetia papyrifera*, an ornamental species found within the city of Podgorica, has spread rapidly due to vegetative reproduction and has started to outcompete *Ailanthus altissima*. Recently, pampas grass (*Cortaderia selloana*), a species on the EPPO list of invasive alien plant species (http://www.eppo.org/QUARANTINE/ias_plants.htm), has been used in landscaping of city

lawns and parks. Consequently, we expect this species to join the list of other alien species escaped from cultivation within Podgorica.

The comparative spectra of the alien floras of Rome, Patras, Podgorica, and Salonika are given in Fig. 3.

With the exception of Patras, where South American taxa dominate, a common feature of the alien floras of the compared cities is the prevalence of taxa having Asian origin. The majority of these taxa were introduced as ornamentals. In all spectra, species of Australian origin have very low participation or are completely missing (Patras, Salonika).

Values of the Sørensen index show the greatest similarity between the alien floras of Podgorica and Rome (52.7%, see Table 4). In view of the similarity in taxonomic structure of these two floras (Stešević and Jovanović, 2008) and similar climatic conditions, such a result was expected.

Observing the trends in floristic composition over the past two centuries, many authors noted an obvious decrease in the number of native species. According to Sukopp (1973), during the period from 1850 to 1950, some European cities faced extinction rates between 4 and 16%. The example of Warsaw (Sudnik-Wojcikovska, 1987) shows that over a period of 150 years, 15% of native species became extinct, while for Zürich the rate for the last 160 years was only 5.7% (Landolt, 2001). For the Czech industrial city of Plzeň, the decrease of native species was 11.5% over the past 120 years (Chocholouškova and Pyšek, 2003).

One of the most drastic examples of general floristic loss is the case of Turnhout, Belgium, where nearly 25% of the flora became extinct between 1888 and 1990 (Van der Veken et al., 2004).

The loss of native flora due to spreading of alien species is a phenomenon known as biotic homogenization (McKinney and Lockwood, 1999, 2006; Olden et al., 2004; La Sorte and McKinney, 2006).

The aforementioned unplanned rapid urbanization causes on the one hand a loss of native species and on the other creates space for expansion of already established and newly introduced alien species. We expect that the effects of biotic homogenization will be evident soon.

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ФЛОРА ГРАДСКОГ ПОДРУЧЈА ПОДГОРИЦЕ, ЦРНА ГОРА – ХОРОЛОШКА СТРУКТУРА И УПОРЕДНА АНАЛИЗА СА ФЛОРАОМА РИМА, ПАТРАСА И СОЛУНА

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Хоролошки спектар Подгорице рашчлањен је на IX ареал типова, с тим што нативној компоненти флоре припада 85.9 %, а алохтоној 14.1 %. Релативно низак удео алохтоне компоненте јесте генерална одлика медитеранских насеобина чији, чак и најурбанизованији сегменти у великој мери одсликавају карактер флоре окружења.

Посматрано на нивоу ареал типова у хоролошком спектру доминирају врсте широког распострањења (IX: 30.3 %) и евроазијског (V: 26.5 %). У погледу ареал група као доминантне се истичу еуримедитеранска (18.2 %), космополитска (12.6 %) и стеномедитеранска група (8.3 %). Посебан печат спектру флоре дају ендемични и субендемични таксони (6.8 %).

У оквиру евроазијског ареал типа бројем врста се издвајају евроазијска група у ужем смислу (7.7 %) и палеотемпорална (5.1 %). Бореални ареал тип је заступљен са 5.2 %, у оквиру којег се истичу циркумбореална (2.6 %) и еуросибирска група (2.5 %). Атлантски елемент је заступљен са 2.2 %.

Удео адвентивне компоненте у флори Подгорице износи 14.1 %, што се може сматрати за релативно малу вредност. Објашњавамо је малом старошћу насеобине, као и до недавно лоше развијеном транспортном и трговинском мрежом.

У спектру алохтоне флоре Подгорице као доминанте су присутне врсте азијског и северноамеричког порекла, а највећи број врста се сматра за "одбегле из културе".

Упоређујући спектре флора Подгорице, Рима, Патраса и Солуна уочили смо низ сличности: доминацију елемената широког распрострањења и приближан удео космополитске и алохтоне флоре; висок удео медитеранског елемента (стеномедитеранског, еуримедитеранског, медитеранско-монтаног и медитеранско-туранског); доминацију азијског елемента у структури алохтоне флоре као и најмању заступљености или потпуно одсуство аустралијског елемента.

С обзиром на наглу и непланску урбанизацију, која с једне стране узрокује губитак нативне компоненте флоре, а са друге ширење већ постојећих и појаву нових алохтоних врста, очекујемо да ће тренд биотичке хомогенизације бити ускоро евидентан и на подручју Подгорице.