Acta Bot. Croat. 59(1), 135–143, 2000

CODEN: ABCRA 25
ISSN 0365–0588
UDC 581.5 (450)

Dedicated to Prof. dr. LJUDEVIT ILIJANIĆ on the occasion of his 70th birthday.

Phytoecological research in the urban environment in Italy

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The main characteristics of the Italian urban flora are discussed and its use as a synthetic indicator of environmental conditions is illustrated. The study of urban allergophytes enables a correlation to be made between their phenanthesic period and signs of allergy in a town's inhabitants. Also discussed is a method of evaluating the quality of urban environment by ecological analysis of the flora and vegetation.

Key words: plant ecology, urban environment, flora, bioindicators, pollen, allergen, Italy

Introduction

Increase in urban areas worldwide, the overcrowding of cities, alterations in ecological conditions, together with an increasingly higher level of pollution, call for in-depth ecological research into the urban environment. To obtain results which can be used for assessing the urban sustainability, a multidisciplinary approach is required. Once the structure and dynamics of an urban ecosystem are known, it becomes easier to manage ecological problems and relate them with the economic, social, and political ones. In fact, the main task of urban ecology is to set up and maintain favorable conditions for the life of the human population, and to program and organize the heterogeneous urban territory with its numerous plant and animal species.

The results of some investigations into Italian urban flora and vegetation given below confirm the importance of plant ecological research in the urban environment.

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Materials and methods

The present study makes use of the results obtained from aut- and synecological investigations carried out on the vegetation of the Italian urban ecosystem (HRUŠKA 1994, 1998). These began with an ecological analysis of the urban flora; then, to assess its diagnostic significance with respect to the overall ecological conditions of a certain area, the ecological characteristics of individual species were examined, and both partial and complete lists of the flora drawn up. The data obtained allowed ecograms of the most significant urban biotopes to be made, while the direct influence of the vegetation on the human population was verified by means of investigation of urban allergophytes. The synanthropic vegetation study, aimed at assessing the quality of the urban environment, was based on typological and structural analyses of individual vegetation units.

The elaboration of Tab. 1 and Fig. 2, was performed according to: BRANDES (1985), CANEVA et al. (1995), HRUŠKA (1985,1987, 1995, 1998), and HRUŠKA and VALENTI (1993)

Results

Urban flora

A city's flora is influenced by numerous factors such as geographic position, the geologic and topographic features of the zone, climate, the number of inhabitants per square kilometer, their main activities, historical background, etc. Despite geographic and historical-cultural differences between various cities, their urban flora has certain features in common. For example, a study carried out on a sample of approx. 1700 plants in 14 Italian cities revealed that 11% of the species were common to all the cities considered (HRUŠKA 1994). Instead, a higher percentage (15%) was found when comparing flora from some central European cities (KOWARIK 1990, SUKOPP 1998). The greater heterogeneity of Italian urban flora is attributable both to geographic and cultural factors, on the one hand, and on the other to the marked presence of Mediterranean species which, favored by the urban climate, have successfully settled in this environment.

From the qualitative point of view, the prevalent species belong to the families of the *Compositae,* the *Leguminosae,* the *Graminaceae* and the *Cruciferae.* Nomenclature of plant species and families follows PIGNATTI (1982). The overall number of families varies, but a trend towards constant increase of the first two is observed, with all the negative effects connected with the increase of allergenic pollen in the air. However, despite the marked variability of ecological factors in a city, there is a considerable similarity of flora between the various urban districts. For centuries, the anthropic factor has led to a selection of the flora, favoring those species able to develop in such ecological conditions. The floristic stability found in the urban centers has determined the development of characteristic associations belonging to the *Parietarietea diffusae* class, which are very important in the Italian urban landscape.

Selection of urban flora and competition for space are above all influenced by the anthropic factor; in fact, various allochthonous species brought into the city voluntarily or involuntarily by man are particularly favored. Trade, tourism, and

wars can also facilitate floristic exchanges and the spreading of plants in various geographical areas. The exotic contingent coming from America, Asia, or other parts of the world cause the local flora to regress, and often these new plants have highly allergenic pollens. Most of them found the habitat idoneous for the development in the urban ecosystem such as *Eleusine indica* (ILIJANIĆ 1989). In addition, the spreading of vigorous and competitive species (i. e. *Conyza albida*, *C. bonariensis*, *C. canadensis*, *Erigeron karvinskianus*, *Aster squamatus*, *Amaranthus deflexus*, *Ambrosia artemisiifolia*, *Artemisia verlotorum*) in certain urban biotopes involves a decrease in biodiversity and change or loss of the characteristic physiognomy of the preexistent vegetation.

The increase of widely distributed species, and particular of the cosmopolitan ones, which is a more marked feature of cities and metropolises, leads to banality, decline, and a qualitative leveling out of the spontaneous local flora. The increase in human population density per square kilometer enhances this process: urbanization, in fact, promotes the presence of species with wide ecological range, a dynamic process more evident in the suburbs where highly unstable environments are abundant and the local flora offers less resistance to the entrance of allochthonous species.

The geographic gradient usually becomes significant for the quality of urban flora over considerable distances, as can be deduced from the corograms reported in Fig. 1. Comparison of the urban flora from the 14 Italian cities shows that the differences between the main corological groups are more marked between the northern and southern cities than between those and the central Italian ones.

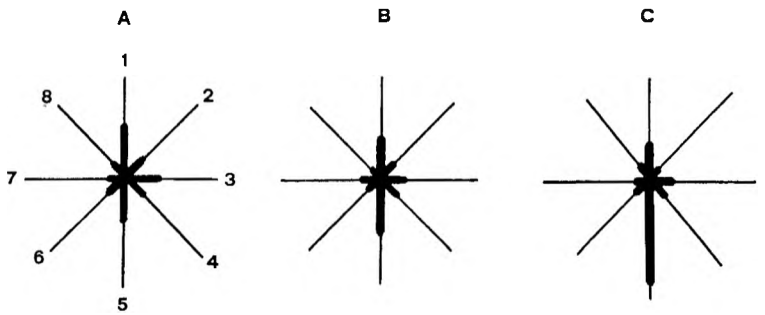

Fig. 1. Corograms of Italian urban flora: A – Northern Italy (Torino, Milano, Pavia, Padova, Trieste), B – Central Italy (Bologna, Rovigo, Siena, Perugia, Ascoli Piceno), C – Southern Italy (Napoli, Bari, Palermo).
Corological types: 1 – Cosmopolite, 2 – Circumboreal, 3 – Neophytes and cultivated species, 4 – Paleotemperate, 5 – Mediterranean, 6 – Europaean, 7 – Eurasiatic, 8 – Eurosibiric; modified from Hruska 1994)

Urban flora as an indicator of environmental conditions

Several ecological indices have been elaborated in central Europe by utilizing the ecological valence of individual species (LANDOLT 1977, ELLENBERG 1979). The factors considered, expressed on a numerical scale, were light, tem-

perature, continentality of climate, soil humidity, soil pH and soil nutrients. In so far that plants can synthetically represent several ecological factors, they have thus become bioindicators for quantifying them and to characterize ecologically a certain association or even the whole biotope.

Using the Ellenberg indices (l.c.) ecograms for the central Italian urban biotopes were elaborated, the sources of information for which are reported in the References. The ecograms are obtained from the average values of the six ecological factors considered. As can be deduced from Fig. 2., the urban flora possesses a high diagnostic value respect to the site ecological conditions. A comparison of the ecograms shows that the most homogeneous values are those recorded for soil pH and nutrient content. This uniformity is the result of anthropic action which in the urban biotopes leads to a neutral reaction of the soil and considerably enriches it with nutrients. In particular, the nitrogen content is somewhat high in all urban biotopes, which explains the abundance of nitrophilous or nitro-tolerant species in the urban flora. The greatest differences between the biotopes regard the values for humidity and air temperature, which become determinant for selection of urban flora and the formation of plant communities. The correspondence between the values obtained and the real situation confirms the validity of employing indexes to acquire the necessary database for assessing the quality of a whole urban ecosystem. The management of the urban green spaces should take into account, when new species are introduced, the ecograms obtained from the area in question.

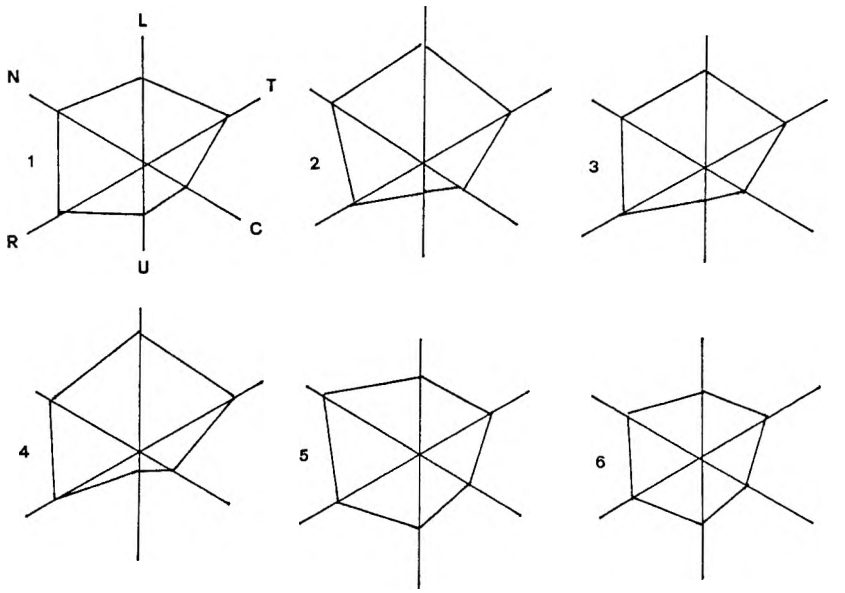

Fig. 2. Ecograms of urban vegetation of Central Italy (L-light, T-temperature, C-continentality, U-humidity, R-soil reaction, N-nitrogen; 1-walls, 2-trampled areas, 3- road and footh path verges, 4-dry ruderal sites, 5-shady sites, 6-parks and urban woodlands)

Allergenicity

The study of the main features and dynamic trends of the urban flora and vegetation of cities situated in a certain geographic area facilitates the control of some of their negative effects on the human population. One example is the presence of various allergophytes in the composition of urban flora, among which *Parietaria diffusa* and *Urtica dioica* are common in all Italian cities and possess highly allergizing pollen (D'AMATO et al. 1992, HAUSEN and VIELUF 1998). These are followed by pollens of the *Graminaceae* and the *Compositae* families, including various extraneous species introduced by man and often abundantly present in and around the urban territory.

The research carried out on central Italian urban allergophytes shows that a correlation exists between the phenanthesic maximum of certain plant communities and the incidence of allergopathy among the inhabitants (TELLONI and HRUŠKA 1997). Once the high percentage of allergophytes has been established in the urban vegetation structure (Tab. 1), it is then indispensable to indicate the species and associations most responsible for the increase of allergic symptoms among the inhabitants of a city, as well as the period of maximum flowering. With this aim in view, phenological observations and phenograms made for certain urban ecosystems prove very useful (KOPECKÝ 1990): it is thus feasible not only to keep the most dangerous species under control, but also to eliminate them thereby reducing the amount of allergenic pollen in the air.

Quality assessment of the urban environment

The ecological conditions of the urban ecosystem lead to the development of a particular vegetation, the structure and physiognomy of which depend on the type and duration of the anthropic factor which is responsible for selecting the

Tab. 1. Presence (%) of allergophytes in the Italian urban vegetation

Vegetation	Allergophytes (%)
Asplenietum trichomano-rutae muriariae Kühn 1937	66.6
Centrantho-Parietarion Riv. Mart. 1960	52.0
Capparidetum inermis O. Bolos et R. Molinier 1958	55.5
Parietario diffusae-Amaranthetum deflexi Hruska 1998	55.6
Hordeetum murini Libb. 1932	60.0
Lolio-Polygonetum arenastri Br.-Bl. 1930 em. Lohm. 1975	65.0
Trisetarietum aureae Hruska 1998	59.8
Ornithogalo-Leopoldion comosae Hruska 1995	45.3
Cardario drabae-Agropyretum repentis Müller et Görs 1969	52.0
Echio italici-Pastinacetum urentis Hruska 1995	47.5
Sambucetum ebuli (Kaiser 1926) Br.-Bl. (1936) 1952	43.8
Conietum maculati Pop (1965) 1968	47.4
Urtico-Aegopodietum Tx. 1963	3.8
Alliario-Chaerophyllietum temuli (Kreh 1935) Lohm. 1949	48.6
Anthriscetum nemorosae Hruska 1981	47.5

species, putting together in similar areas those having similar ecological needs. Interacting by various dynamic strategies, the plants try to make optimal use of the available environmental resources. The anthropic factor, the ecological characteristics and the relationships set up between the species, all influence the type of community that develops in a certain urban biotope.

Following the spatial gradient from the city center to the suburbs, numerous types of vegetation can be observed, starting from those already introduced and the perennial ones, by way of biennials to those of shorter duration, annuals or seasonal. Through their floristic composition, dynamics and structure, these express the level of equilibrium achieved between the abiotic and biotic factors and man.

The scarcity of available areas and their high degree of heterogeneity increase competition among plants in the city. To have the ecological niche they need for completing their life cycle, the communities follow a spatial and temporal succession. This is very evident in biotopes exposed to multiple disturbance, as for example those at the edges of roads or on the banks of artificial rainwater collection channels.

Despite the previously mentioned geographical and historical-social differences between various cities, the vegetation which develops in the same urban biotopes has similar floristic, structural, and dynamic characteristics. The most important ones are: walls, trampled areas, dry ruderal sites, shady sites, road and footh path verges, parks and town woodlands, gardens, riverbanks and banks of artificial channels and the residuals of natural ecosystems. Following the geographical gradient from nothern to southern Italy, numerous associations, often vicarious ones, develop in these biotopes.

Assessment of the urban environment quality allows to obtain the necessary information for improving ecological conditions and making them more suitable for the life of human population. To shorten costs and time of research into individual ecosystems, the data obtained by use of specific groups characteristic for individual urban biotopes have proved to be very useful. The partial lists of flora are made, drawn up on the basis of the diagnostic values of individual species and of the connection with the ecological conditions of certain urban biotope. The spreading of these species over the urban area is verified by means of selective floristic cartography (HRUŠKA 1998). Those species identified as drivers facilitate the recognition and mapping of the urban biotopes by establishing their diffusion over the city. The urbanization level of the individual biotopes, expressed with a numerical scale from 1 to 10 which indicates the progressive increase of the anthropic factor, correlates its with the environmental ecological conditions. The subsequent assessment of partial characteristics for each of the chosen biotopes regards its position in the urban area, its age, rarity, historical continuity, vulnerability, naturalness, landscape value, allergenicity, diversity, the presence of fauna, etc.

An example of the overall evaluation of the quality of an urban ecosystem is reported in Tab. 2. This should be integrated with the data on the cultivated urban greenery introduced by man for ornamental reasons. The final results may be represented by means of computerized cartography, dividing the urban territory

Tab. 2. Evaluation of some partial characteristics of urban biotopes through the ecological analysis of the urban flora and vegetation of central Italy (modified from HRUSKA 1998)

Urban biotope	Guide- species	Urban vegetation (phytosociological category)	Urbanization (level)	Position (zone)	Biotope age (class)	Rarity (degree)
Trampled areas	*Polycarpon tetraphyllum*	*Polycarpion tetraphylli*	10	1	5	4
	Plantago major	*Polygonion avicularis*	10	1	5	4
	Trisetaria aurea	*Polycarpion tetraphylli*	10			
Walls	*Capparis spinosa*	*Parietarietea diffusae*	9	1	5	5
	Centranthus ruber	*Parietarietea diffusae*	9	1	5	5
	Cymbalaria muralis	*Parietarietea diffusae*	9	1	5	5
	Erysimum cheiri	*Parietarietea diffusae*	9	1	5	5
	Parietaria diffusa	*Parietarietea diffusae*	9	1	5	5
	Sedum album	*Sedo-Scleranthetea*	9	1	5	5
Gardens	*Euphorbia peplus*	*Polygono-Chenopodietalia*	8	3	1	2
	Mercurialis annua	*Polygono-Chenopodietalia*	8	3	1	2
	Veronica persica	*Polygono-Chenopodietalia*	8	3	1	2
Parks and town woodlands	*Alliaria petiolata*	*Glechometalia hederaceae*	7	1,2,3	3,4,5	2
	Chelidonium majus	*Glechometalia hederaceae*	7	1,2,3	3,4,5	2
	Silene alba	*Glechometalia hederaceae*	7	1,2,3	3,4,5	2
	Parietaria officinalis	*Glechometalia hederaceae*	7	1,2,3	3,4,5	2
Road and footpath verges	*Amaranthus deflexus*	*Chenopodion muralis*	6	2,3	1,2	1
	Muscari atlanticum	*Ornithogalo-Leopoldion*	6	2,3	1,2	1
	Lactuca serriola	*Sisymbrietalia*	6	2,3	1,2	1
	Malva sylvestris	*Sisymbrietalia*	6	2,3	1,2	1
	Agropyron repens	*Convolvulo-Agropyrion*	6	2,3	1,2	1
Dry ruderal sites	*Linaria vulgaris*	*Agropyretea interm.-repentis*	5	2,3	2,3	1
	Melilotus officinalis	*Sisymbrietalia*	5	2,3	2,3	1
	Echium italicum	*Pastinacion sativae urentis*	5	2,3	2,3	1
Shady sites	*Smyrnium olusatrum*	*Alliarion*	4	2,3	2,3	2
	Chaerophyllum temulum	*Alliarion*	4	2,3	2,3	2
	Anthriscus nemorosa	*Anthriscion nemorosae*	4	2,3	2,3	2
	Ranunculus lanuginosus	*Anthriscion nemorosae*	4	2,3	2,3	2
	Symphytum bulbosum	*Anthriscion nemorosae*	4	2,3	2,3	2
Riverbanks and banks of artificial channels	*Calystegia sepium*	*Convolvuletalia sepium*	3	3	3	3
	Helianthus tuberosus	*Convolvuletalia sepium*	3	3	3	3
	Pastinaca sativa	*Pastinacion sativae urentis*	3	3	3	3
Residuals of natural ecosystems	*Quercus pubescens*	*Quercetalia pubescentis*	2-1	3	5	5
	Cornus sanguinea	*Prunetalia*	2-1	3	5	5

into various zones according to the index of urban environmental quality (UEI, HRUŠKA 1997) obtained by considering the values found for the partial characteristics.

Conclusions

Urban flora and vegetation have a direct impact on man: they can influence the urban climate, favour the introduction of fauna, cause deterioration of the architectural heritage, or improve the environmental conditions of degraded zones. Moreover, various plants precisely indicate the level of pollution reached in a given urban area.

The data regarding the vegetation of an urban ecosystem facilitate its ecological management. Once the high diagnostic value of the urban component has been demonstrated, with respect to the ecological conditions at individual urban sites, it can be employed for indicating the correct use of the urban space and projecting the recreational areas aimed at optimal utilization of the zone. The use of phenological observations regarding urban allergophytes allows those periods of the year to be identified which are more dangerous for persons who suffer from allergies. Reducing the abundance of these plants in given urban zones leads to a decrease of allergenic pollen in the air.

The phytosociological informations acquired on urban vegetation facilitate the choice of interventions for reclaiming degraded areas and restoring the urban landscape. When managed correctly the public green areas can mitigate the negative effects of the urban climate for the inhabitants, moderate drought and increase humidity, absorb dust and reduce the noise of traffic or of industry. All these examples confirm the importance of plant ecological research applied to the urban environment, and the results obtained, when integrated with those of other disciplines, will lead to the creation of environmentally sustainable urban ecosystems.

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