

## TAXONOMICAL ANALYSIS OF RUDERAL FLORA (*sensu stricto*) IN AREA OF THE CITY OF KRAGUJEVAC

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**ABSTRACT.** This paper presents analysis concerning ruderal flora (*s.s.*) of the city of Kragujevac. The research included ruderal habitats on the territory of the Kragujevac. The list of ruderal flora species included only those species that are typical representatives and indicators of ruderal habitats. The species spontaneously present in ruderal habitats, but which are typical for natural and anthropogenically unimpaired habitats, were not included in the list of species of ruderal flora. During the floristic research conducted, 185 vascular plant species were recorded and divided into three classes, 37 families and 129 genera. The ruderal flora of the city of Kragujevac comprises three families, with 10 and more genera, where family Asteraceae has the biggest number of species. There are 13 genera represented by three or more species. The most numerous are genera *Vicia* and *Veronica*.

**Key words:** Kragujevac, ruderal flora, Serbia.

### INTRODUCTION

Ruderal flora develops in urban and rural settlements and other areas with pronounced direct or indirect human activity. Other names used for the flora in the human settlements are synanthropic, synurban and nitrophile flora.

The main reason for the presence of this group of plants in anthropogenically altered habitats is their wide ecological valence, i.e., adaptation to the complex effects of anthropogenic factors.

Floristic composition and stage of development of the ruderal flora and vegetation are very important data in seeing all consequences of more and more intensive process of global urbanization and a high degree of destruction of natural habitats. The ruderal plant species are subject of numerous researches (SLAVNIĆ, 1951; MARKOVIĆ, 1964; JOVANOVIĆ, 1994; PAVLOVIĆ-MURATSPAHIĆ, 1995; MOSYAKIN and YAVORSKA, 2002; MA and LIU, 2003; JOVANOVIĆ, 2001; JAKOVLJEVIĆ and JOVANOVIĆ, 2004; TOPALIĆ-TRIVUNOVIĆ, 2005; STANKOVIĆ-KALEZIĆ, 2007), because they follow human activity and they are part of the environment.

In several successive studies carried out by some of authors, the quantitative-qualitative composition of the ruderal flora was determined for the territory of the city of Kragujevac. Besides data for whole territory of the city, there are data for some of its settlements, too (MARINKOVIĆ, 2000; NINKOVIĆ, 2005).

The aim of our research was determination of quantitative-qualitative composition and importance of the ruderal flora on the territory of the city of Kragujevac.

### **General characteristics of investigated area**

Kragujevac basin is located in the central part of the Republic of Serbia, and also in the central part of Šumadija. It is lined by the branches of Šumadija's mountains: Rudnik, Gledičke mountains and Kragujevac's Crni Vrh. Geographic position of Kragujevac is determined by the coordinates 40° 02' N and 22° 50' E. The Kragujevac basin covers the area of 452 km<sup>2</sup>, which constitutes 7.4% of the total surface of Šumadija. It is situated at an altitude of 210 m. The highest point is located at 895 m, and the lowest at 130 m above sea level (STEPANOVIĆ, 1974).

Geological substrate is made up of neogenic sediments of middle and upper Miocene age, sandstone, clay and marl. Smonica and smonica in the process of browning are types of soil that are present in the highest percentage in Kragujevac valley (TANASIJEVIĆ, 1957).

Hydrographic network is made of greater number of rivers, which are poor in water because of weak sources and lack of rainfall. The largest river is Lepenica with its tributaries: Drača River, Divostin stream, Erdoglija stream, Sušica stream, Petrovac River and Cvetojevac stream from the left, and Grošnica River, Ždraljica, Bresnica stream and Komarnice stream, from the right side.

There are no natural lake basins, and artificial lake basins are: Grošničko reservoir, Duleni reservoir, Memorial Park reservoir and Bubanj reservoir.

The climate is temperate continental, and it is characterized by a cold and moderate wet winters, while summers are hot and dry. The average annual temperature for period from 1951 to 1970 years was 11.2°C, and annual precipitation for the same period was 713 (STEPANOVIĆ, 1974).

In phytogeographical respect, this area belongs to the Illyrian province of the Eurosiberian-Northamerican subregion. Climatogenic vegetation consists of communities of characteristic oak forest, ass. *Quercetum frainetto-cerris moesiacum* Rudski ap. Ht. 1946 (HORVAT *et al.*, 1974).

The ruderal habitats, both in the inner as well as the wider city area, are: nitrified ruderal areas with presence or absence of waste, belts along the roads, edge sidewalks and footpaths, thermophilic habitats along the walls, fences, dams and railway lines, extremely nitrified area such as dumps and landfill waste, moderately wet to dry ruderal surfaces from river bank material, sand, gravel and rocks, as well as construction material, waste and tailings. Moderate to extremely nitrified abandoned arable land with less expressed presence of anthropogenic factors such as trampling, grazing and mechanization. Wet nitrified ruderal areas along the banks of rivers, streams, lakes and ponds, hygrophilic ruderal habitats on sandy-muddy shores and occasionally flooded parts of the coasts.

## **MATERIAL AND METHODS**

Floristic study of the ruderal flora of the city of Kragujevac were carried out during two full vegetation periods of 2007-2008, from February to November. The study covered the territory of the city of Kragujevac. Plant material was processed and herbarised in the laboratory of the Institute of Biology and Ecology, Faculty of Sciences, University of Kragujevac. Identification of plant species was carried out using the appropriate literature (JOSIFOVIĆ, 1970-1977; TUTIN, 1964-1980; JAVORKA & CSAPODY, 1975). Herbarial collection with 185 specimens is archived in the herbarium of the Institute of Biology and Ecology, Faculty of Sciences, University of Kragujevac.

## **RESULTS AND DISCUSSION**

Because of the intense process of global urbanization and a high degree of destruction of natural ecosystems in urban areas very diverse habitats are present. Ruderal habitats are characterized by dramatically altered climate, edaphic and orographic conditions. A factor which is

largely expressed in almost all habitats, and directly and indirectly affects the intensity and quality of other factors in the ruderal habitats is anthropogenic factor (SUKOPP and WURZEL, 2003; TASIĆ *et al.*, 2006; PAVLOVIĆ-MURATSPAHIĆ, 1995; JOVANOVIĆ, 1994).

The great diversity and dynamics of ruderal habitats result in a characteristic qualitative-quantitative composition of ruderal flora. The presence of species which are customized to the extreme and changing conditions on the ruderal habitats by their habitus and ecophysiological features is much expressed. However, in addition to large urban ecosystem dynamics, regularity in the floristic composition of some urban areas is recorded; this is the result of the connection between ecological characteristics of the habitat and ecological affiliation of species that inhabit it.

Researchers of ruderal flora and vegetation of the territory of former Yugoslavia included in ruderal flora all plants that are in the area researched: Belgrade (JOVANOVIĆ, 1994), Banja Luka (TOPALIĆ-TRIVUNOVIĆ, 2005), Pale (PETRONIĆ, 2006), Kragujevac (MARINKOVIĆ, 2000), Vranje (JOVANOVIĆ, 2001).

In this paper, we have another approach to the ruderal flora of Kragujevac which is already used in research ruderal flora of Sarajevo area (PAVLOVIĆ-MURATSPAHIĆ, 1995). Ruderal flora and vegetation consists of plants that are best adapted to anthropogenically altered environmental conditions. In the scope of anthropogenic vegetation are the following classes: Chenopodietea Br.-Bl. 1951, Artemisietea Lohm., Prsg. et Tx. 1950, Plantaginetea Majoris Tx. et Prsg. 1950, Bidentetea tripartiti Tx., Lohm. et Prsg. 1950. Class Secalinetea Br. Bl. 1951 was partially included because the majority of its plants are at the same time field weeds. Ruderal plants are typical for these types of vegetation - class level or lower syntaxonomic categories (OBERDORFER, 1962).

The all habitats of the city of Kragujevac are not equally anthropogenically influenced and changed - ruderal. A large part of the city belongs to the well-kept green areas that in more or less level urban greenery maintains. They grow from grass seeding mixture on "arranged land", and later are maintained by mowing. Conditions for the development of meadow vegetation are created in this way. In populated areas, these surfaces are often exposed to waste and throwing waste, with increased air pollution, and always is held in them a degree of anthropogenic influence. Meadow species, that have wide ecological valence in relation to anthropogenic factors, are commonly occur here: *Taraxacum officinale*, *Bellis perennis*, *Achillea millefolium*, *Trifolium repens*, *Plantago lanceolata*, *Dactylis glomerata*, *Arrhenatherum elatius*, *Poa trivialis*, *P. pratensis* and others, and also inhabit those ruderal species, *Cichorium intybus*, *Daucus carota*, *Malva sylvestris*, *Capsella bursa-pastoris*, *Plantago major*, *Poa annua* etc.

Some ruderal surfaces are forsaken for a long time, they are rarely mowed in the fall or early spring, so they are left to natural progradation of vegetation. Here, ruderal species remain for a long time, but beside them meadow species are included, which can survive on habitats of ruderal vegetation. In time, herbaceous species are settling, shrub and lianas, which are characteristic for the hedgerows and fence of order Prunetalia Tx. 1952. and the surrounding forest vegetation: *Glechoma hederacea*, *Galium cruciata*, *G. aparinae*, *Geum urbanum*, *Humulus lupulus*, *Clematis vitalba*, *Salix alba*, *S. fragilis*, *Cornus sanguinea*, *Rubus caesius*, *R. fruticosus*, *Rosa canina*, *Prunus spinosa*, *Lycium europaeum*, *Hedera helix*, *Crataegus monogyna*, *Acer tataricum* etc.

There are species that develop optimally in ruderal vegetation, and they are regular members of mesophilic meadows, such as *Crepis biennis*, *Daucus carota*, *Cichorium intybus*, *Pastinaca sativa* and others, because mesophilic meadows are, always, to some extent under anthropogenic influence.

Some species can be considered as indifferent in relation to the type of vegetation, but for their presence some environmental factor has a crucial role: the increased amount of organic matter - *Aegopodium podagraria*, humidity - *Rubus caesius*, *Ranunculus repens*, *Lysimachia nummularia*, and large amounts of nitrogen compounds - *Urtica dioica*, *Onopordon acanthium* etc.

Some species are grown in culture, and their presence is evident in ruderal vegetation and in the surrounding natural vegetation: *Robinia pseudoacacia*, *Avena sativa*, *Medicago sativa*, *M. falcata* and others.

There are species that are allochthonous for this area, and according to the different types of vegetation they spread with greater or less speed: *Ailanthus altissima*, *Amorpha fruticosa*, *Reynoutria japonica*, *Galinsoga parviflora*, mostly in hoeings, *Stenactis annua* in meadows and vegetation of hedges, *Ambrosia artemisifolia* in arable land and ruderal vegetation.

Table 1. List of ruderal flora species of the Kragujevac;

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**Amaranthaceae:** *Amaranthus retroflexus* L., *A. albus* L., *A. blitoides* Watson; **Apiaceae:** *Aegopodium podagraria* L., *Anthriscus sylvester* (L.) Hoffm., *A. trichospermus* (Spr) Arc., *Chaerophyllum aureum* L., *Ch. temulum* L., *Daucus carota* L., *Pastinaca sativa* L.; **Aristolochiaceae:** *Aristolochia clematitis* L.; **Asteraceae:** *Ambrosia artemisifolia* L., *Anthemis arvensis* L., *Arctium tomentosum* Mill., *A. lappa* L., *Artemisia vulgaris* L., *Armoratia lapathifolia* Gilib., *Bidens cernua* L., *B. tripartitus* L., *Chamomilla recutita* L., *Carduus acanthoides* L., *Centaurea calcitrapa* L., *Cichorium inthybus* L., *Cirsium arvense* (L.) Scop., *C. lanceolatum* (L.) Scop., *Coryza canadensis* L., *Crepis bienis* L., *C. capilaris* (L.) Wallr., *C. setosa* Hall., *Eupatorium cannabinum* L., *Galinsoga parviflora* Cav., *Helminthia echiodes* L., *Hieracium racemosum* W. et K., *Inula britannica* L., *Lapsana communis* L., *Matricaria inodora* L., *Onopordon acanthium* L., *Pircis hieracioides* L., *Pulicaria dysenterica* (L.) Bernh., *Senecio vulgaris* L., *S. vernalis* W. et K., *Solidago canadensis* (L.) Cult., *Sonchus arvensis* L., *S. oleraceus* L., *Stenactis annua* (L.) Ness., *Tanacetum vulgare* L., *Taraxacum officinale* Web., *Tussilago farfara* L., *Xanthium strumarium* L.; **Boraginaceae:** *Anchusa arvensis* (L.) M. B., *A. officinalis* L., *Echium vulgare* L., *Myosotis arvensis* (L.) Hill., *Symphytum officinale* L.; **Brassicaceae:** *Alliaria officinalis* Andr., *Barbarea vulgaris* R. Br., *Bertheroa incana* (L.) DC., *Brassica nigra* (L.) Koch., *Calepina irregularis* Thel., *Capsella bursa-pastoris* (L.) Med., *Cardamine hirsuta* L., *Erophila verna* (L.) Chevall., *Lepidium campestre* (L.) R. Br., *L. draba* L., *Rorippa lippizensis* (Wulf.) Rchb., *R. sylvestris* (L.) Bes., *Sinapis arvensis* L., *Sysimbrium loeselii* Insl., *S. officinale* (L.) Scop., *Thlaspi alliaceum* L., *T. arvense* L.; **Caprifoliaceae:** *Sambucus ebulus* L.; **Caryophyllaceae:** *Arrenaria serpyllifolia* L., *Cerastium glomeratum* Thuil. *Cucubalus bacifer* L., *Melandrium album* (Miller) Garcke, *Saponaria officinalis* L., *Silene vulgaris* (Mnch.) Gar., *Stellaria media* (L.) Vill.; **Chenopodiaceae:** *Chenopodium album* L., *Ch. polyspermum* L., *Ch. hybridum* L., *Atriplex patula* L.; **Cuscutaceae:** *Cuscuta europaea* L.; **Convolvulaceae:** *Convolvulus arvensis* L., *Calystegia sepium* (L.) R. Br.; **Cyperaceae:** *Carex hirta* L.; **Dipsacaceae:** *Dipsacus sylvester* Huds., *Scabiosa ochroleuca* L.; **Euphorbiaceae:** *Euphorbia helioscopia* L., *E. falcata* L.; **Equisetaceae:** *Equisetum arvense* L.; **Fabaceae:** *Coronilla varia* L., *Galega officinalis* L., *Lathyrus tuberosus* L., *Medicago arabica* (L.) All., *M. lupulina* L., *M. sativa* L., *Melilotus albus* Med., *M. officinalis* (L.) Pall., *Ononis arvensis* L., *Trifolium incarnatum* L., *T. repens* L., *Vicia hirsuta* (L.) S.F.Gray., *V. lutea* L., *V. pannonica* Grantz, *V. sativa* L., *V. tetrasperma* (L.) Schreb.; **Geraniaceae:** *Erodium cicutarium* (L.) Herit., *Geranium columbinum* L., *G. dissectum* Jusl., *G. molle* L., *G. rotundifolium* L.; **Lamiaceae:** *Ajuga genevensis* L., *Balota nigra* L., *Galeopsis speciosa* Mill., *Lamium amplexicaule* L., *L. album* L., *L. maculatum* L., *L. purpureum* L., *Leonurus cardiaca* L., *Mentha pulegium* L., *Salvia verticillata* L.; **Malvaceae:** *Althea officinalis* L., *Malva sylvestris* L.; **Onagraceae:** *Epilobium parvifolium* Schreb.; **Oxalidaceae:** *Oxalis corniculata* L.; **Papaveraceae:** *Chelidonium majus* L., *Papaver dubium* L., *P. rhoeas* L.; **Poaceae:** *Agropyrum repens* (L.) Pers., *Avena sativa* L., *Bromus inermis* Leyss., *B. mollis* L., *B. sterilis* L., *Cynodon dactylon* (L.) Pers., *Hordeum murinum* L., *Lolium multiflorum* Lam., *L. perenne* L., *Panicum crus-galli* L., *Poa annua* L., *Setaria glauca* (L.) P. B., *S. italica* (L.) P. B., *S. verticillata* (L.) R. et S., *S. viridis* (L.) P. B., *Sorghum halepense* (L.) Pers.; **Polygonaceae:** *Bilderdykia convolvulus* L., *Polygonum aviculare* L., *P. lapathifolium* L., *P. mite* Schr., *P. persicaria* L., *Rumex obtusifolius* L., *R. acetosella* L., *R. conglomeratus* Murr., *R. crispus* L.; **Portulacaceae:** *Portulacca oleracea* L.; **Plantaginaceae:** *Plantago major* L.; **Primulaceae:** *Anagalis arvensis* L.; **Ranunculaceae:** *Consolida regalis* SF.Gray., *Ranunculus arvensis* L., *R. repens* L., *R. sardous* Cr.; **Resedaceae:** *Reseda lutea* L.; **Rosaceae:** *Potentilla reptans* L., *Prunus domestica* L. subsp. *insititia*

(L.) C. K. Scheider; *Rubus caesius* L.; **Rubiaceae**: *Galium aparinae* L.; **Scrophulariaceae**: *Linaria vulgaris* Mill., *Scrophularia nodosa* L., *Verbascum blattaria* L., *V. lychnitis* L., *V. nigrum* L., *Veronica hederifolia* L., *V. persica* Poir, *V. polita* Fr., *V. serpyllifolia* L. *V. agrestis* L., *V. opaca* Fries, *V. arvensis* L.; **Simaroubaceae**: *Ailanthus altissima* (Mill.) Swingle; **Solanaceae**: *Solanum nigrum* L.; **Urticaceae**: *Urtica dioica* L.; **Valerianaceae**: *Valerianella locusta* (L.) Latt., *V. dentata* (L.) P.; **Verbenaceae**: *Verbena officinalis* L.;

During the floristic researches of ruderal flora so far conducted on the territory of the city of Kragujevac, it was established the presence of 185 species of vascular plants, divided into 2 divisions, 3 classes, 37 families and 129 genera. Class Equisetopsida is represented with one species, class Magnoliopsida with 167, while 17 species belong to the class Liliopsida (Table 2).

Table 2. Representation of species, genera and families in the ruderal flora of the city of Kragujevac;

Class	Number of families	%	Number of genera	%	Number of species	%
Equisetopsida	1	2.70	1	0.78	1	0.55
Magnoliopsida	34	91.89	117	90.70	167	90.27
Liliopsida	2	5.41	11	8.53	17	9.19
<b>Total</b>	<b>37</b>	<b>100.00</b>	<b>129</b>	<b>100.00</b>	<b>185</b>	<b>100.00</b>

The composition of the ruderal flora of the city of Kragujevac includes 3 families with 10 or more genera, where the most numerous are the family Asteraceae with 31 genera and 38 species, family Brassicaceae with 13 genera and 17 species, and the family Poaceae with 10 genera and 16 species (Table 3).

Table 3. The families represented with 10 and more genera in the ruderal flora of the city of Kragujevac.

Family	Number of genera	%
Asteraceae	31	24.03
Brassicaceae	13	10.08
Poaceae	10	7.75
<b>Total</b>	<b>54</b>	<b>41.86</b>

In the ruderal flora of the city of Kragujevac, the most common are species from the most numerous families in the entire flora of Serbia. This composition with the most represented families of ruderal flora occurs, also, in the flora of several cities investigated in Serbia. The families Asteraceae, Brassicaceae and Poaceae are the most numerous in the flora of Belgrade (JOVANOVIĆ, 1994), Smederevska Palanka (JAKOVLJEVIĆ and JOVANOVIĆ, 2004), Vranje (JOVANOVIĆ, 2001) and Pančevački rit (STANKOVIĆ-KALEZIĆ, 2007). Results of researches of ruderal flora and vegetation of cities outside of Serbia, also show that the aforementioned families are with the largest number of genera and species. In the ruderal flora of Banja Luka (TOPALIĆ-TRIVUNOVIĆ, 2005), 14 families with over 10 representatives were found, where the composition of the first five, which are the most numerous, is identical to composition of the ruderal flora of the city of Kragujevac. Comparing results for ruderal flora of the city of Kragujevac with researches of ruderal flora of major cities in the world, such as Kiev (MOSYAKIN and YAVORSKA, 2002) and Beijing (MA and LIU, 2003), we found, beside great differences in climate conditions and surface investigated and the degree of urbanization, the composition of first five the most numerous families is exactly the same, but with differences in the order of the listed families.

The six families are with more than ten species, while 15 families are presented with less than ten and more than one species. In the ruderal flora of the city of Kragujevac, 16 families are with only one representative.

Table 4. The genera represented with 3 and more species in ruderal flora of the city of Kragujevac.

Genera	Number of species	%
<i>Veronica</i>	7	3.78
<i>Vicia</i>	5	2.70
<i>Rumex</i>	4	2.16
<i>Geranium</i>	4	2.16
<i>Lamium</i>	4	2.16
<i>Setaria</i>	4	2.16
<i>Polygonum</i>	4	2.16
<i>Ranunculus</i>	3	1.62
<i>Bromus</i>	3	1.62
<i>Chenopodium</i>	3	1.62
<i>Crepis</i>	3	1.62
<i>Verbascum</i>	3	1.62
<i>Medicago</i>	3	1.62
<i>Amaranthus</i>	3	1.62
<b>Total</b>	<b>53</b>	<b>28.65</b>

In the ruderal flora in the city of Kragujevac, 14 genera with three or more species were registered. With the highest number of species, seven or five, respectively, are genera *Veronica* and *Vicia*. Majority of the species which belong to these genera are characteristic indicators of tertiary ruderal vegetation. In comparison with the results for other cities (JOVANOVIĆ, 2001; JAKOVLJEVIĆ and JOVANOVIĆ, 2004; STANKOVIĆ-KALEZIĆ 2007; TOPALĆ-TRIVUNOVIĆ, 2005; JOVANOVIĆ, 1994), there are similarities in terms of the most representative genera, and mostly those with species that are typical indicators of ruderal flora and vegetation. The differences exist only in quantitative-qualitative composition, as a result of differences in climatic conditions and different degree of urbanization. Because of the mentioned reasons, there is a deviation in comparison with the number of species of ruderal flora for the areas investigated. Also, the reasons for the discrepancy in the number of species are the size of the cities investigated and the absence of the species that are non typical habitat for ruderal flora in the list of Kragujevac.

Based on the data obtained and comparative analysis of ruderal flora, it can be noted a large quantitative representation of species whose presence is characteristic for different ruderal habitats, in relation to the species that are elements of natural, anthropogenically undisturbed habitats.

Ruderal plants as part of the human environment have great significance. Their positive role in urban areas, as part of urban greenery, is reflected in the production of oxygen, the assimilation of carbon dioxide and pollutants from the air, as well as protection against noise. In addition to the positive role of ruderal plants, their habitats are characterized by some negative features. Some ruderal plants are a source of allergens, while ruderal habitats are nursery of weeds and undesirable allochthonous species. (MATOVIĆ, 1997).

## CONCLUSION

In so far floristic studies of the city of Kragujevac about 450 plant species were recorded. The ruderal flora consists of plants that are best adapted to environmental conditions, and which are characteristic for ruderal vegetation of a class and lower-level of syntaxonomic categories. On the territory of the city of Kragujevac, 185 ruderal species that are classified into three classes, 37

families and 129 genera make the ruderal flora. The families with the greatest number of genera are Asteraceae, Brassicaceae and Poaceae. 14 genera were recorded with three or more species, and the genera with the largest number of species are *Veronica* and *Vicia*. In the ruderal flora of the city of Kragujevac, the most represented are species from the most numerous families in the flora of the Serbia.

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