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Are the urban and periurban adventive plants a potential threat factor for diversity of the autochthonous flora in Serbia?

Abstract

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First data on the adventive plants in Serbia date from XIX century, but the intensive studies begin in the last fifty years. At the beginning the records of new adventive species were commented as one way of enriching flora. It was, however, noted that some species spread sub spontaneously, and rarely even spontaneously, but that was not considered very important. Today, when we know how important it is to preserve the natural diversity of the autochthonous flora and vegetation, the presence of the adventive plants must be considered to be a threatening factor. As a rule, these plants come from the remote biogeographic areas, and in the new habitats have neither natural enemies nor competition. They mostly have the low ecological requirements and the high level of ability to adjust. Some of these species spread very aggressively, especially in areas where the natural vegetation is disturbed or destroyed, and habitats devastated. By occupying that space, they disable the natural reversible processes of the autochthonous flora. After they enter the natural vegetation, they cause the relationship changes within communities, and lead to the serious disturbance of the natural succession. Factor of the introduction and further spreading of the adventive plants, both direct and indirect, is always anthropogenous. The urban and periurban areas, where the anthropogenous influence is most intensive and diverse, are the real "nurseries" of the adventive plants. From these habitats many species spread sub spontaneously, and some of them have already conquered habitats of the natural vegetation. It is unrealistic to expect total protection of the diversity of autochthonous flora and vegetation from the negative influence of the adventive plants. However, through use of the appropriate preventive and protective measures, the role of urban and periurban habitats in the appearing and spreading of the adventive plants could be significantly reduced.

Introduction

It has been known for a long time that the anthropogenous influence on the forming and changing the plant cover of a region is not an achievement of the modern times. The results of the palinological and phytogeographical analyses are showing that this process started already in the prehistoric times. Due to the lack of transport devices, the anthropogenous influence was in that time limited to much smaller areas, but that is the very factor that enabled long existence in the limited area.

In ancient ages, Greek and Roman civilization were followed by the intensive changes in the plant ranges on the three continents, far away from the boundaries of the Mediterranean area. Even then, many plant species were deliberately and on purpose brought in the areas where there were previously absent, in order to be used for food, medicinal purposes or raw material for various products. In the same time, many plants spread without any will and deliberation from the humans, but as a result of their various activities. During the great people moving in the Middle Ages, the anthropogenous influence was especially pronounced along the migration routes and in the places where the permanent or temporary settlements were built. The further development of the industry, agriculture, trade and transport directly influenced the increase in intensity of changes of the plant world under the human influence.

This was the origin of a very heterogeneous group of the plants, *anthropochores*, whose ranges under human influence spread to the areas where they could not arrive only with the help of their diasporas. Although varying regarding the classification, taxonomy and biogeography, as well as biological and ecological characteristics, these plants are connected by the anthropogenous influence during the spreading process as their key common factor.

A special group within the anthropchores is the adventive plants.

This term stems from the Ancient Latin words *adventicius* and Modern Latin *adventivus*, meaning foreign, alien, the one who came from afar, but also unusual, strange, accidental, marginal, one who does not grow in its proper place. All these meanings perfectly fit the characteristics of this group of the plants.

Although the cases when they are widely distributed within a certain area are not rare, the adventive plants are not a part of the autochthonous flora, and they did not reach that place by the natural continuous spread of their ranges. Their presence is exclusively a result of either a direct or an indirect anthropogenous influence. The autochthonous ranges of these plants are by the rule situated in the very far biogeographical areas, and in Europe these are the plants whose origin is in American continent or in faraway areas of Asia, Africa or Australia. Not only the geographic distance but also the insurmountable relief barriers (oceans, seas, high mountains, long mountain chains) are the reason why these plants could come to European continent only with human interference.

According to the chronological classification of the anthropochores (Trinajstić 1975) the adventive plants may be: *neophytes* – introduced in the period between discovery of the new continents and the World War II, and *neotophytes* – introduced after the World War II.

The routes, ways and the means of the arrival of these plants into the new areas are very different, but always connected with the human activities. Their introduction, and especially further sub spontaneous or spontaneous spreading and forming the secondary range in a new area are mostly accidental and out of the human control.

As they are aliens, the adventive plants have no natural enemies in their new environment for a long time, and they are also not included in the competition relationships that were before their arrival arranged during a long time period among the autochthonous plants. They usually have low demands toward the ecological conditions, but a high degree of the ability to adapt to the new environment.

In the early phases of the settling these plants arrive and occupy the habitats formed by

anthropogenous influence, which are either devoid or low in competition. Therefore they mostly grow in the ruderal and devastated habitats of the urban areas and their vicinity, and secondarily they spread along the traffic routes. However, these exact areas often become starting points from which some adventive plants arrive to agricultural areas where they act as weeds, and increasingly also to habitats of the natural vegetation.

Although, according to the abundance and importance, the adventive plants cannot compete with the members of the autochthonous flora, there is still a whole array of the serious reasons why research on them is necessary. One of the most important reasons is the fact that some plants, which are invasive in character, after they are initially introduced into urban and periurban areas in the course of time become a threat factor for natural diversity of the autochthonous flora and vegetation.

The urban and periurban adventive plants in Serbia

The earliest data on the presence of the adventive plants on the territory of Serbia date from the end of the XIX Century. In his first work on the flora of then Serbia, Pančić (1856) cited the species: *Acorus calamus*, *Chenopodium ambrosioides*, *Xanthium spinosum,* and *Phytolacca americana*, as growing mostly in ruderal habitats in the urban areas. The first data for Vojvodina, then part of the Austria-Hungary, were recorded by Godra (1872) and Zorkoczy (1896), and pertained to *Oxalis stricta, Acorus calamus,* and *Phytolacca americana.*

The intensive research on the adventive plants, which was not limited just on the recording presence of the species, started in Serbia in mid XX century (Slavnić 1953, 1961, 1962; Atanacković 1958; Babić & Parabućski 1961; Obradović 1962). Besides the monitoring of the first appearance, dynamics of spreading and distribution of the localities, some papers include data on the ecological conditions during the process of settling and naturalization of certain adventive species (Obradović 1976; Šajinović & Koljadzinski 1978; Obradović & Budak 1979), as well as the data on species that already became members of the autochthonous associations (Slavnić 1952; Parabućski 1973; Obradović & Butorac 1975; Ivković & Čapaković 1979; Obradović & Budak 1979; Obradović & al. 1980).

For Serbia so far there are records of somewhat over 110 species of adventive plants. The greatest number is indigenous to the American continents, as many as about 90 species, most of which (about 70) are native to the area of North America. Several species originate from the far-away eastern Asia, from Africa and Australia.

About a hundred adventive species, when compared with about 3700 species and subspecies in flora of Serbia, may seem quite insignificant. However, with these plants the number is least important, while far more important are the type of occupied habitat, the size of occupied area, distribution, the coverage of occupied space, the population density, the speed of spreading, and especially the influence on the autochthonous flora and vegetation.

As the anthropogenous factor is of utmost importance for the process of settling and further spreading of the adventive plants, they are best represented in the areas with the greatest anthropogenous influence. These are primarily habitats within human settlements and the wider or smaller area around them, as well as along the traffic routes that connect these

settlements. Regardless of the size, each urban area represents a mosaic of artificial or modified habitats that are very attractive for the adventive plants, while especially suitable are so-called anthropogenous or urban deserts (Vasić 1984). These are usually large areas prepared for the urban development and then abandoned for years. Almost as a rule, the adventive plants are first to settle there, and often they continue to keep a dominant role during the later successions of the ruderal vegetation.

This principle of the initial settling and early spread of the adventive plants is also present in Serbia. It is especially characteristic for the territory of Vojvodina, as in that region there are the first records of the most adventive plants present today in Serbia (Slavnić 1953, 1960, 1962; Babić & Parabućski 1961; Šajinović & Koljadzinski 1966, 1981; Budak 1975; Šajinović 1976; Parabućski & al. 1977; Tinajstić 1978; Ivković 1978; Obradović & al. 1978; Bož a 1979; Ivković & Budak 1979; Ivković & Čapaković 1979; Obradović & al. 1981; Koljadzinski & Šajinović 1982; Bož a & al. 1996; Pavlović & al. 1998; Blaženčić & al. 2000). As a part of the Pannonian plain, Vojvodina is geographically close to Middle Europe (place of the earliest records for most American species) and it is also not protected with more significant relief-created or ecological barriers that would stop spreading of the adventive plants. On the other hand, Vojvodina is a pronounced agricultural area, thickly settled and with a well-developed transportation network. All these conditions have undoubtedly favored a far higher degree of the settling and spreading of the adventive plants in Vojvodina when compared with the southern parts of Serbia. For a fairly long time it was even assumed that Vojvodina was predestined for spread of the adventive plants, and that the mountain character of the Balkan part should represent a natural protection. It was also assumed that rivers Sava and Danube, which are the natural boundary between Pannonian and Balkan part of Serbia, represent a serious barrier, stopping the spread of the adventive plants toward south. Records of the adventive plants, primarily in the urban areas, even in the southernmost parts of Serbia (Domazet 1979; Ivković 1979, 1981, 1982; Bož a & al. 1980; Bogojević 1983; Vasić 1988, 1990, 1998) clearly show that these estimates were not realistic. It seems that not enough attention was paid to role of the humans in spreading of the adventive plants, as this factor consciously or unconsciously helped them to overcome even the more serious barriers.

Although Vojvodina is the main region (Obradović & Panjković) through which the majority of the ruderal and weed adventive plants arrived to Serbia from the north, some plants anyhow came from other directions, and a certain number was deliberately introduced for various reasons (Bož a & al. 1996; Pavlović & al. 1998; Vasić 1998).

The further behavior of the adventive plants, initially settled in urban and periurban areas, is influenced by a whole array of various factors: biological and ecological characteristics of plants themselves, conditions offered by various types of habitats in closer or further surroundings, as well as degree of the anthropogenous factor and the way it works.

Certain species remain permanently in urban, mostly ruderal habitats, and besides their influence on esthetic look of the landscape, their presence is not disturbing. In Serbia, such species are: *Amarantus crispus, Amarantus deflexus, Chenopodium ambrosioides, Eleusine indica, Galinsoga ciliata, Oxalis stricta, Chamomilla suaveolens* (Ivković 1975;Čapaković & Ivković 1978; Bož a 1979a; Ivković & al. 1980; Ivković & Čapaković 1981; Jovanović 1985). They grow in the streets, along main buildings and outbuildings, in courtyards and gardens.

The most common species on ruderal and disturbed land adjacent to the settlements are: *Amarantus retroflexus, Xanthium spinosum, Asclepias syriaca, Conyza canadensis, Erigeron annuus, Galinsoga parviflora*, *Phytolacca americana*, *Oenothera muricata* (Ivković 1975; Obradović & Budak 1978, 1979; Obradović 1981; Obradović & al. 1981; Jovanović 1994).

However, for the weed species, habitats in cities are only the starting base for claiming of agricultural areas in further or closer vicinity. Therefore, the already mentioned species *Amarantus retroflexus, Conyza canadensis, Galinsoga parviflora,* as well as *Ambrosia artemisiifolia*, *Iva xanthifolia*, *Nicandra physaloides*, *Cuscuta arvensis, Panicum capilare* act as more or less dangerous weeds (Koljadzinski & Šajinović 1973; Ivković & Čapaković 1979; Čapaković & Ivković 1980; Obradović 1981). The most dangerous and least desirable are the weed species *Ambrosia artemisiifolia* and *Iva xanthifolia.*

On the territory of Serbia, both these species were for the first time recorded in Novi Sad, the capitol city as well as the greatest city of Province of Vojvodina (Slavnić 1953; Šajinović & Koljadzinski 1966). In the early phases of the spreading, both these species managed to survive in grassy and ruderal habitats in settlements and the surroundings. Today both of these species are widespread in Vojvodina and grow abundantly as weed plants, especially in maize fields, but also with other cultivated plants. The spread of the species *Ambrosia artemisiifolia* was for whole 30 years limited only to Vojvodina. It appeared on several localities to the south from Sava and Danube since 1984 (Vasić 1988), and the newest research shows the tendency of further spread. However, in the Balkan part of Serbia, *A. artemisiifolia* still inhabits the ruderal habitats in cities and their surroundings.

Both species represent a striking and alarming example of the weed species using the anthropogenous habitats in the urban and periurban areas as the first step on the route to invading cultivated fields, where they quickly assume the dominating role among the autochthonous weeds.

Today, there are various biological and chemical means to suppress or at least diminish the effects of weeds in agricultural areas. Most countries also have very strict quarantine measurements that are applied when importing seeds of the agricultural plants. This immensely helps in preventing the introduction of new weeds of foreign origin. As humans are directly interested in increase of the harvest in fields, a great care is paid to the problem of protection from weeds, whether they are native or adventive.

In Serbia, still only a small amount of attention is paid to those adventive plants that potentially may arrive to habitats of spontaneous vegetation. As from ecological, biological and chorological point of view they are in certain conditions advantaged when compared to autochthonous vegetation, these plants may become a very dangerous threat factor. By initiating a whole array of unnatural processes, they may lead to negative consequences for diversity of autochthonous flora and vegetation. Initially introduced into urban and periurban habitats, in following phases they spread to devastated or modified habitats of natural vegetation. By occupying the area where the natural vegetation was previously destroyed, adventive plants prevent its renewal even after the ceasing of the negative factors. After the entering the natural vegetation, they conquer new areas pushing away, limiting or stopping the growth of autochthonous species. This inevitably leads to change of the natural floristic structure during a very short period of time, while forming of that

structure needed a long evolutionary time. Besides, the adventive plants cause the changes in relationships within the associations and disrupt the natural flow of successions. Often the whole looks of association changes, as new members, especially if they play a dominant role, give some features of their own.

Species such as *Bidens frondosa, Galinsoga parviflora, Impatiens parviflora, Solidago serotina, Asclepias syriaca, Amorpha fruticosa, Ailanthus altissima, Robinia pseudoacacia*, and others, in Serbia already penetrated the remains of spontaneous vegetation thriving near urban and periurban areas (Slavnić 1952; Parabućski 1973; Parabućski & al. 1989; Panjković & Stojšić 2001).

The defeating fact is that most of these species were from various reasons deliberately introduced and planted. Then in the most cases no or a little attention was paid to the way these plants behave in their homeland, and the expected behavior in new environment was not previously researched or estimated. For some species there were even excuses in form of their objectively positive characteristics, which however in new environment and without the appropriate competition relationships enabled these plants to spread outside of the planned and controlled areas. Some of these species already in great measure found their own place in the areas where previously there was developed spontaneous vegetation, so it is even forgotten that they were not here from time immemorial.

A classical example is an American species *Robinia pseudoacacia*, which is today for its distribution among forest trees in Serbia on the third place, just after the autochthonous *Fagus* and *Quercus* species (Diklić 1972). Few persons know that this tree, which entered the folk lore and superstitions and which is sang about in songs, was introduced in Europe in XVII, and in Serbia only in XIX century. As a melliferous plant, the Black Locust is very eagerly planted in the periurban areas throughout Serbia. Spacious plantations of the Black Locust are situated in Deliblatska Peščara sands (Vojvodina) where this species has been planted in order to bind sand. Therefore, the space for renewal of the natural steppe vegetation was greatly reduced. In the Balkan part of Serbia, this species was used in order to reforest the devastated areas, so in areas of autochthonous vegetation in lowland and hill regions there are very common almost monodominant Black Locust forests.

Amorpha fruticosa is almost the only species growing in damp ditches and near channels along the roads. In the marshy areas along the greater rivers (Danube, Sava, Morava, Tisa) in many places it completely suppressed the autochthonous species or took over a dominant role. There it perfectly expresses its characteristics, the ability to suddenly and abundantly spread, but also great resistance to various factors and the fact that it is difficult to eradicate. To all this attention was not paid in 1865, when a large quantity of seed was obtained in order to plant this species as an ornamental plant in Belgrade and several spas in Serbia.

The unilateral approach and insufficiently wide and far estimate of possible consequences of a basically positive intention can when dealing with the adventive plants lead to very dangerous consequences. The best example for this, not only in Serbia but in many other European countries, may be the species *Ailanthus altissima,* whose origin is the far away areas of China.

Introduced in Europe in late XVIII century, this luxuriant tree is planted as decorative tree, but also as a pioneering species for ameliorating soil in the area for plantation forests. Biological and economic qualities of this plant are indisputable, provided that its spread-

ing is strictly controlled, which is not the case in Serbia. In all development stages, it grows amply in different habitats in urban and periurban areas.

In Belgrade, this plant is almost literally met on every step, and in certain places there are already real coppices. Old tall trees with luxuriant crown are also not rare any more. On territory of Serbia, there is almost no human settlement without at least several specimens of this plant. If *Ailanthus altissima* stayed only in urban and periurban areas, its presence in Serbia perhaps would not be so worrisome. However, this species started to move from urban areas toward the autochthonous vegetation. It unstoppably spreads on the slopes along roadsides and in devastated areas. From there, it already entered areas with spontaneous vegetation, and in Eastern Serbia entered the gorges.

Considering the already obvious tendency of this plant's spreading as well as the negative influence on autochthonous flora, the article from half a century ago (Radulović 1952), where this plant is suggested and advertised, is today a complete nonsense. In that article, the author vented that planting of *Ailanthus altissima* in Serbia is neglected, and as a positive example he cites Italy and France where it already became a real forest species. Cited as advantages of this species are: the pronounced ability to adapt to new environmental conditions, the resistance to low temperatures and even frost, quick spreading, abundant fruit-bearing, as well as successful development of forests even in hilly and mountain areas. At that time it was unimaginable even to think that today's knowledge on the importance of conservation of natural diversity of autochthonous flora and vegetation will give the negative connotations to these characteristics and that *Ailanthus altissima* will be included in the list of extremely unwanted plants.

Herbaceous plants such as *Conyza canadensis*, *Erigeron annuus*, *Solidago gigantea*, *S. canadensis*, *Impatiens parviflora*, *Asclepias syriaca* and few others became members of vegetation that develops on flooded and wetland habitats along rivers (Slavnić 1952; Parabućski 1973; Obradović 1976).

It is interesting to note how the recently recorded species on the shore of artificial lake in Belgrade *Paspalum paspalodes* (Blaženčić & al. 2000) spread also to Danube shores almost with lighting speed. This was enabled by a seemingly quite harmless pastime such as fishing. Places where this plant overgrows the shore are bothering the fishermen, so they cut the bunches and let them flow downstream.

Comments and recommendations

In the Mediterranean and Balkan areas, the studies are mostly directed to the autochthonous flora, and that is well reasonable if we consider its great importance for understanding the geohistorical, evolutionary, chorological and biogeographical processes in the formation of plant cover in Europe. Besides, flora of this area is characterized by a high degree of diversity regarding the classification, taxonomy, ecology and vegetation, necessitating an intensive research. It is the proven fact that in absolute values of abundance adventive plants lag far behind the autochthonous species of this area, and the research may look unattractive both considering the geographical position of the localities and the ecological characteristics of habitats where they appear.

However, as warmest parts of Europe, these areas have been densely populated since

time immemorial, and therefore constantly and continuously under anthropogenous influence. Led by their wish to fulfill their needs, humans have even unconsciously created conditions for introducing and spreading of the adventive plants. Centuries of destruction or disturbance of the natural structure within the climatogenous and zonal forest vegetation, led to start of the degradation succession that in turn induced formation of the modified and devastated habitats. This process went even further by building and increasing the size of the human settlements and traffic network. Thus various types of the anthropogenous habitats were created, as a rule with low quality regarding the ecological conditions, where only the most resistant and the least needy plants can survive. In most cases, it is the representatives of the adventive plants that arrive and remain there.

From the initial habitats in the urban and periurban areas, some adventive plants during time also penetrate into the habitats of spontaneous vegetation. As these plants are from ecological, biological and chorological viewpoint advantaged in certain conditions, they may become a very serious and dangerous threat factor to natural diversity of autochthonous flora and vegetation.

Although research of the adventive plants may seem less important when compared to the autochthonous flora, these plants deserve full attention exactly because the aspect of the protection and conservation of the natural diversity.

The stopping or at least control and limiting of the spread of adventive plants, especially those that are in other areas already characterized as invasive, are possible only if based on the fair knowledge of their characteristics and behavior.

Therefore it is very important to register each appearance of a new species, as well as to follow its spreading, including distribution of localities, dynamics of conquering the new areas and the ecological characteristics of the habitat.

In order to prevent, it is necessary to know well the ecological, biological and the chorological characteristics of the plants that already appeared or spread in the neighboring areas.

Deliberate introduction of the non-native plants, regardless of cause, use or excuse, should be under a strict control. Without a previous knowledge of the biological, ecological and chorological characteristics in their native country, and a realistic estimate of the expected behavior in new environment, introduction of no species should be allowed. As much as temporary gain might seem a justifiable reason, estimate of far-reaching consequences should be a crucial factor when forming a decision.

It is very important to limit or at least decrease areas of anthopogenous habitats where the adventive plants initially are introduced, and that become bases for their further spread.

However, all these preventive and protection measurements will have almost no effect if there is no adequate, permanent and complete protection of the autochthonous flora and vegetation, and if there is no conservation of the natural state and characteristics of the appropriate habitats.

The attitude with a positive connotation that adventive plants enrich the flora (although they do enrich it in absolute abundance) should be left in the early and perhaps romantic ages when appearance of a new adventive species was a floristic curiosity of its own kind, because the answer to the question posed in the title is YES!

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