

ALIEN AND INVASIVE PLANTS IN CAREI PLAIN NATURAL PROTECTED AREA, WESTERN ROMANIA: IMPACT ON NATURAL HABITATS AND CONSERVATION IMPLICATIONS

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Abstract. *The alien invasive plants from the Carei Plain Natural Protected Area affect all its natural habitats. The diversity of the habitats from the area allows the existence of certain alien species with diverse ecological requirements. Most of the species were observed on the sand dunes, but the swamps are also strongly affected. Still, the greatest concentration of species is recorded in the cleared areas near human settlements, highly anthropogenically affected, this most likely being a reservoir from where the alien species are spreading into the natural habitats. Ambrosia artemisiifolia is extremely dangerous, which inhabits the sand dunes, practically covering them. The species has favorable conditions in the area and is likely to proliferate here. A highly negative influence is that of the acacia trees, too, which also cover part of the sand dunes and are currently spreading to newer areas as well. A first step in limiting the impact of these plants would be to identify the least affected habitats and to protect them.*

Key words: *protected area, biodiversity, alien plants, invasion, habitat.*

INTRODUCTION

Invasive species represent one of the most important threats to biodiversity, their impact being extremely negative, sometimes with fatal consequences to the local species (see in: Reshetnikov 2003, Sanders et al. 2003, Stinson et al. 2006, Rödder 2009, Stiers et al. 2011). The negative impact of the invasive species is accentuated by the economic implications that some of them have (e.g. Van Wilgen et al. 2001, Pimentel et al. 2005, Vilá et al 2010). Aside from the practical side, worries regarding the impact of invasive plants on natural protected areas have increased in number in the last few years (e.g. McKinney 2002, Pyšek et al. 2003a, Foxcroft et al. 2007). The seriousness of the phenomenon was felt in Romania, too, where numerous invasive plant (e.g. Anastasiu & Negrean 2007, Anastasiu et al. 2007, Hodişan et al. 2008, Hodişan & Morar 2008, Sîrbu & Oprea

2010) and animal (e.g. Pârvulescu et al. 2009, Copilaş-Ciocianu & Pârvulescu 2011, Covaciu-Marcov et al. 2011, Tăușan & Markó 2011) species were signaled recently. In this context, we set out to analyze the alien plants from the newly established Carei Plain Natural Protected Area from Romania. This is a Natura 2000 Site, which protects numerous special habitats and species, out of which the Pannonian sand dunes are remarkable – a community interest habitat (O.U.G. 57 / 2007). The region stands out because the presence of some mountain related species present in the plain (Karácsonyi 1987), a particularity noted in the case of the fauna as well (e.g. Ardelean & Karácsonyi 2005, Covaciu-Marcov et al. 2009). Thus, it is crucial to determine the impact of alien plant species on this special region. Therefore, we aimed to find out which are the alien plant species inside the protected areas and which are the most affected habitats.

MATERIAL AND METHODS

The study took place in the years 2010 and 2011. We covered almost all Carei Plain Natural Protected Area by foot. This area is located in north-western Romania, on the border with Hungary. We firstly intended only to establish which the alien and invasive species from the area are, which the habitats that they occupy are and in which way they affect them. Thus, we limited ourselves to the direct observation method. We also analyzed the previous data on invasive plants in the area (Ardelean & Karácsonyi 2005, 2008). The species were determined using the specialty literature (Ciocârlan 2009). Some species and habitats were photographed. We analyzed the distribution of the foreign plants in the region, depending on habitat. Thus, we examined the main natural habitats (sand dunes – 5, swamps – 8 and forests - 1) as well as the artificial and affected ones (plantations – 3, grasslands – 2, hayfields – 5 and cleared areas around human settlements - 6). Since the study followed gathering data on alien and invasive plants, some specimens were collected and conserved.

RESULTS

In the Carei Plain Natural Protected Area we identified 114 alien and invasive species, 83 of them being recorded for the first time in the studied area. They were separated into two categories: adventive and local invasive species, which represent the greatest threat to the natural area (Table 1) and plants that got away from cultures planted in the area or adventive noninvasive (Table 2). Among the 83 species, 70 are alien adventive, being atypical for the region, and only 13 are colonizing local

plants, which breed excessively as a consequence of the human impact in the area. Among the invasive plants, most species (28) affect the sand dunes. This habitat advantages the xerophilous invasive species, being naturally only covered by scarce, grassy vegetation, which allows an easy installation of invasive plants. The swamps are next, being affected by 19 species, and then the natural forests, affected by 6. Among the artificial habitats, the most affected are the cleared areas near human settlements, where all the invasive species in the region were identified.

Table 1. Adventive and autochthonous invasive plant species from Carei Plain natural protected area (Adv. – adventive, G – geophite, H – hemicriptophite, Ch – camephite, Ph – phanerophite, Th – annual therophite, TH – biannual therophite, Subsp. – subspontaneous, Cult. – cultivated, ☼ - sand dunes, ▲ – natural forests, ▼ – planted forests, — - wetlands, ■ – grasslands, ● – antropogenically affected areas).

Species	Bioforms	Adv./ Subsp./ Cult.	Habitat
<i>Cannabis sativa</i>	Th	Cult. / Subsp.	☼●
<i>Cannabis sativa ssp. spontanea</i>	Th	Ruderal plant	☼●
<i>Urtica dioica</i>	H	Ruderal plant	☼●▲▼—
<i>Phytolacca americana</i>	H	Cult. / Supsp.	●▲▼
<i>Portulaca oleracea</i>	Th	Adv.	☼●
<i>Amaranthus hybridus</i>	Th	Adv.	☼●
<i>Amaranthus powellii</i>	Th	Adv.	☼●
<i>Amaranthus retroflexus</i>	Th	Adv.	☼●
<i>Chenopodium album</i>	Th	Ruderal plant	☼●▼■
<i>Fallopia japonica</i>	G	Cult. / Supsp.	☼●—
<i>Padus serotina</i>	Ph	Cult. / Supsp.	▼▲—●
<i>Amorpha fruticosa</i>	Ph	Cult. / Supsp.	—■●
<i>Robinia pseudacacia</i>	Ph	Cult. / Supsp.	▼▲☼●—■
<i>Rhus hirta</i>	Ph	Cult. / Supsp.	—●
<i>Chaerophyllum bulbosum</i>	TH-H	Ruderal plant	●▼▲
<i>Echinocystis lobata</i>	Th	Adv.	—■●
<i>Asclepias syriaca</i>	H	Cult. / Supsp.	☼●
<i>Cuscuta campestris</i>	Th	Adv.	■●

Table 1. (continued)

Species	Bioforms	Adv./ Subsp./ Cult.	Habitat
<i>Sambucus ebulus</i>	H	Ruderal plant	☀️●▲▼
<i>Ambrosia artemisiifolia</i>	Th	Adv.	☀️●▼■
<i>Arctium lappa</i>	TH	Ruderal plant	●■—☀️
<i>Arctium tomentosum</i>	TH	Ruderal plant	●■☀️
<i>Artemisia annua</i>	Th	Adv.	☀️●
<i>Aster x salignus</i>	H	Cult. / Supsp.	—●
<i>Carduus acanthoides</i>	TH	Ruderal plant	☀️●
<i>Cirsium arvense</i>	G	Ruderal plant	☀️●■—
<i>Cirsium vulgare</i>	TH	Ruderal plant	☀️●■▼
<i>Conyza canadensis</i>	Th	Adv.	☀️●■▼
<i>Erigeron annuus ssp. strigosus</i>	Th-TH-H	Adv.	☀️●■▼
<i>Helianthus tuberosus</i>	G	Cult. / Supsp.	●—
<i>Iva xanthiifolia</i>	Th	Adv.	●
<i>Onopordum acanthium</i>	TH	Ruderal plant	●■
<i>Solidago canadensis</i>	H	Cult. / Supsp.	—■☀️●
<i>Solidago gigantea</i>	H	Cult. / Supsp.	—■☀️●
<i>Xanthium italicum</i>	Th	Adv.	☀️●■—
<i>Xanthium spinosum</i>	Th	Adv.	☀️●■—
<i>Xanthium strumarium</i>	Th	Adv.	☀️●■—
<i>Calamagrostis epigeios</i>	G	Ruderal plant	☀️●■—▼
<i>Elymus repens</i>	G	Ruderal plant	☀️●

Most of the alien species observed in the Carei Plain Natural Protected Area come from North America, while the Asian, South American, African or Mediterranean species are few. In terms of bioforms, the annual therophytes prevail (Th – 36,14%), followed by phanerophytes (Ph – 24,09), biannual therophytes (TH – 15,66%), hemicriptophytes (H – 13,25%), geophytes (G – 9,63%) and camephytes (Ch – 1,20%). Therophytes are very numerous in the region, the annual and biannual ones summing up half of the number of identified species (51,80%). This fact proves that the sandy soil from many sectors of the protected area

favors annual species, most of them xerophilous or amfi-tolerant. The relatively high number of the adventive tree species is a consequence of the strong alteration of the natural forests from the region, which were replaced with plantations of alien species.

Table 2. Plants got away from cultures or planted in the Carei Plain natural protected area and adventive noninvasive plants (abbreviations form the table: see at Table 1).

Species	Bioforms	Adv./ Subsp./ Cult.	Habitat
<i>Pinus banksiana</i>	Ph	Cult.	▼
<i>Pinus nigra</i>	Ph	Cult.	▼
<i>Pinus sylvestris</i>	Ph	Cult.	▼
<i>Celtis occidentalis</i>	Ph	Cult. / Subsp.	▲▼
<i>Morus alba</i>	Ph	Cult. / Supsp.	▲☀▼●
<i>Juglans regia</i>	Ph	Cult. / Supsp.	▼☀▲
<i>Quercus palustris</i>	Ph	Cult. / Supsp.	▼—▲
<i>Amaranthus albus</i>	Th	Adv.	☀●
<i>Amaranthus hypochondriacus</i>	Th	Cult. / Supsp.	●
<i>Bassia (Kochia) scoparia</i>	Th	Cult. / Supsp.	●
<i>Polygonum orientale</i>	Th	Cult. / Supsp.	☀●
<i>Ribes rubrum</i>	Ph	Cult. / Supsp.	▼▲
<i>Cydonia oblonga</i>	Ph	Cult. / Supsp.	●▼
<i>Prunus cerasifera</i>	Ph	Cult. / Supsp.	●▼
<i>Gleditsia triachanthos</i>	Ph	Cult. / Supsp.	▼☀
<i>Medicago sativa</i>	Ch-H	Cult. / Supsp.	—●■
<i>Vicia angustifolia</i>	Th	Adv.	☀●■
<i>Vicia angustifolia ssp. segetalis</i>	Th	Adv.	☀●■
<i>Oenothera biennis</i>	TH	Adv.	☀●
<i>Vitis vinifera</i>	Ph	Cult. / Supsp.	●
<i>Acer pseudoplatanus</i>	Ph	Cult. / Supsp.	▼▲
<i>Oxalis fontana</i>	H	Adv.	●
<i>Malva sylvestris ssp. mauritiana</i>	TH-H	Cult. / Supsp.	●
<i>Armoracia rusticana</i>	H (G)	Cult. / Supsp. /Adv.	—●
<i>Brassica rapa</i>	Th-TH	Cult. / Supsp.	●
<i>Cardaria draba</i>	H	Adv.	●
<i>Lunaria annua</i>	TH	Cult. / Supsp.	▼▲
<i>Populus x canadensis</i>	Ph	Cult. / Supsp.	▼—

Table 2. (Continued).

Species	Bioforms	Adv./ Subsp./ Cult.	Habitat
<i>Salix matsudana</i> cv. <i>tortuosa</i>	Ph	Cult.	▼ —
<i>Thladiantha dubia</i>	G	Cult. / Supsp.	● ▼
<i>Veronica persica</i>	Th	Adv.	●
<i>Datura stramonium</i>	Th	Adv.	●
<i>Lycium barbarum</i>	Ph	Cult. / Supsp.	● ▼
<i>Callistephus chinensis</i>	Th	Cult. / Supsp.	●
<i>Erigeron annuus</i> ssp. <i>annuus</i>	Th-TH-H	Adv.	● ■
<i>Galinsoga parviflora</i>	Th	Adv.	●
<i>Helianthus annuus</i>	Th	Cult. / Supsp.	●
<i>Inula helenium</i>	H	Adv. / Cult.	— ■
<i>Matricaria discoidea</i>	Th	Adv.	●
<i>Yucca filamentosa</i>	G	Cult. / Supsp.	● ☼
<i>Juncus tenuis</i>	G	Adv.	● — ■ ▼ ▲
<i>Lolium mutiflorum</i>	Th-TH-H	Cult. / Supsp.	● — ■
<i>Panicum capillare</i>	Th	Cult. / Supsp.	● — ■
<i>Sorghum bicolor</i>	Th	Cult. / Supsp.	●

Not all the identified adventitious species affect the natural habitats equally. Some like the common ragweed (*Ambrosia artemisiifolia*) affect massively the areas with sandy soil and have an obvious impact. Moreover, not all the alien plants in the Carei Plain got here accidentally. Some species like the black locust (*Robinia pseudacacia*) were brought here intentionally by people and are presently spreading spontaneously, permanently affecting new territories. We also encountered species that got away from cultures or gardens within the area, namely *Callistephus chinensis*, *Helianthus annuus*, *Polygonum orientale* or *Brassica rapa*. These however don't form significant populations and are even likely to disappear in the future. Species like *Ribes rubrum*, observed in the woods, or *Cydonia oblonga* are becoming sub-spontaneous in the area. Furthermore, *Vitis vinifera* is relatively frequent on the sand dunes where it was used in the past as vines. In the case of this species, the graft disappears over time sometimes and what is left are only the wild species brought from other regions. Aside from the alien species, we also found local species that are spreading uncontrollably in the area due to activities related to agriculture. Among the most common ones of these are:

Calamagrostis epigeios, *Elymus repens*, *Urtica dioica*, *Cirsium arvense* and *Sambucus ebulus*.

Following our study, we identified new species and subspecies of adventitious or sub-spontaneous plants, that had not been signaled before in the region: *Iva xanthiifolia*, *Rhus hirta*, *Amaranthus powellii*, *Aster x salignus*, *Vicia angustifolia ssp. segetalis*, *Malva sylvestris ssp. mauritiana*, *Salix matsudana cv. tortuosa*, *Lunaria annua ssp. annua*, *Brassica rapa ssp. oleifera*.

DISCUSSIONS

The older protected areas present lesser alien plants in comparison to the ones recently established (Pyšek et al. 2003a). Thus, the relatively high number of alien plants from the Carei Plain can be a consequence of the areas recent ascertaining. However, the large number of alien species is probably a result of diversity of habitats in the area, a fact noted in other situations, too (McKinney 2002). The diversity of the habitats allows for the installation of some foreign plants attached to different ecological conditions. The diversity of the habitats from the Carei Plain, that uphold a very diverse fauna (e.g. Ardelean & Karácsonyi 2005, Covaciu-Marcov et al. 2009), has created favorable conditions for a large number of species of alien plants. Meanwhile, the massive presence in the area of alien species could have been aided by the existence of fairly evolved communication paths, these being good dispersion modes of some invasive plants in other cases as well (Pauchard & Alaback 2004). Near the protected area there is a railroad and a main traffic road, from which more secondary roads ramify. Although geographic proximity is, up until one point, advantageous to the invasive plants (Pyšek et al. 2003b), in this region most species originate from far away areas such as America or Eastern Asia. Among the invasive plant species, more than half are of American origin.

Very strongly affected are the sand dunes, which otherwise present a totally remarkable flora and fauna (Ardelean & Karácsonyi 2008, Covaciu-Marcov et al. 2009). Severe is also the impact on the swamps from Carei Plain, which shelter the oldest species in the area, with great biogeographical and conservational value (Karácsonyi 1987, Covaciu-Marcov et al. 2009). In the swamps from the natural protected area we identified some of the most dangerous invasive species for wetlands in Romania: *Amorpha fruticosa*, *Helianthus tuberosus*, *Solidago canadensis* or *S. gigantea* (Anastasiu et al. 2007). The least affected are the forests, a fact documented in other cases as well (Pauchard & Alaback 2004).

However, in Carei Plain this is not a comforting fact, due to the very small surface that the forests cover. Still, the greatest infestation is that from the areas around human settlements. Thus, the spreading of alien plants in the Carei Plain follows the pathways previously established, preferring high temperatures and high disturbance (Jansen et al. 2011).

Presently, the most dangerous alien invasive plant species in the Carei Plain is probably *Ambrosia artemisiifolia*. The common ragweed affects all habitats from the region with the exception of the natural forests. These, however, occupy a small surface and are represented only by two isolated clump of woods. Nevertheless, the habitats preferred by the common ragweed are the sand dunes, which are massively affected. During autumn, the dunes are covered by a uniform carpet of common ragweed where in many cases hundreds of individuals grow on 1 m². The individuals are so many that they suffocate the rest of the herbaceous plants, even the adventitious ones. *A. artemisiifolia* is one of the most invasive plants to the plain regions around Hungary (see in: Pinke et al 2011), being very common in the western part of Bihor county, where it is spreading towards the higher areas (Hodişan et al. 2008). The high abundance of the common ragweed on the sand dunes seems to be a consequence of the sandy soil, favorable to the species (Pinke et al. 2011). The climate factors correspond to the species' demands, which prefers regions with annual average precipitations above 592 mm and average temperatures lower than 15.5°C during the month of May (Pinke et al. 2011), conditions supplied by Carei Plain (Stoenescu et al 1966). The fact that the species finds appropriate conditions in the Carei Plain, and actually in the entire Carpathian basin (Pinke et al. 2011) explains its particular abundance and sets up an alarm with regard to its evolution. Due to its demands, the ragweed is present only at the edge of the swamps and does not enter the areas with permanent humidity. Alongside the natural habitats, the common ragweed is found near agricultural fields, just like in other areas (Pinke et al. 2011).

The black locust is probably even more harmful than the common ragweed. However it is not regarded as such by default also because of some wrong sylvan practices. Thus, if the ragweed reached the area recently and unintentionally, the acacia tree was brought here intentionally and long time ago with the aim of fixing the soil of the sand dunes. Sadly, nowadays the majority of the sand dunes from the Carei Plain are covered with acacia plantations. These not only eliminated the local flora of those dunes, but present an extremely poor invertebrate fauna as well (Tomescu et al. 2008). Even more critical is the fact that the black locust trees are now spreading spontaneously, occupying new sand dunes. The only plant that can massively survive in the black locust plantations is *Bromus sterilis*.

Actually, in the past, this association was observed before, the two species forming the *Bromo sterilis* – *Robinietum pseudacaciae* association (Pócs 1954) Soó 1964 (Sanda et al. 2008). Alongside this association, only plants that grow around human settlements can be found, plants that are easily adaptable (e.g. *Galium aparine*, *Chelidonium majus*, *Geranium pusillum*, *Setaria pumila*, *Ballota nigra*, etc.) and, during autumn, some fungi like *Macrolepiota procera* and *Phallus impudicus*. In order to counteract the massive expansion of the black locust it should, at least partially, be eliminated from the area and replaced with forests of local species (oak, ash, alder) or with xerophilous dune vegetation. Unfortunately the black locust isn't properly monitored in Romania from sylvan considerations foreign to ecology. In this region, this is the most expanding woody alien species, the spontaneous forests from Carei Plain indicating the species' invasive capacity. Alongside acacia trees, the sand dunes are affected by other alien species actively introduced by humans, with sylvan purposes. Thus, in some cases in the area we identified pine plantations (*Pinus sylvestris*, *P. nigra* and *P. banksiana*). The pine plantations, however, take up far less space in comparison to the black locust and unlike it, they do not spread spontaneously in other territories.

Conyza canadensis is another alien species present especially in the anthropogenically affected areas, but which can occur on the sand dunes, too. Because only one plant produces so many achenes (Ciocârlan et al. 2004), some dunes are completely covered by it. Furthermore, the species invades agricultural fields and the abandoned vine plantations as well. *Erigeron annuus* mostly invades hayfields and grasslands, but can occur on the sand dunes. *Solidago gigantea* invades the wet hayfields from the Carei Plain. The species forms compact bushes, thus occupying the local species' space. *Solidago canadensis* is rarer than the above mentioned species. Both species from the *Solidago* genus were brought here from North America for landscaping uses, but are now spreading in many areas of the country, their monitoring being of big importance especially in protected areas (Anastasiu & Negrean 2007). Their presence in the Carei Plain Natural Protected Area is worrying as both are considered some of the most dangerous invasive plants from the wet areas of Romania (Anastasiu et al. 2007). *Asclepias syriaca* has numerous populations in the region, fully occupying the sand dunes. It is interesting how this North American species got here (Ciocârlan 2009) because, as far as we know, it isn't cultivated for landscaping purposes in western Romania. *Padus serotina* is growing abundantly around the marshes, an aspect detrimental for the local bushes. Also around the marsh lands *Quercus palustris* is breeding rapidly. It takes advantage of the microclimate from around the

swamps, a habitat that has allowed the survival of some species thought to be related to mountain areas in Romania (Karácsonyi 1987, Covaciu-Marcov et al. 2009). Again in the swamps we find *Aster x salignus* which during autumn completely covers the swamp from Voivozi.

The pressure put by the invasive plants on the natural habitats from the Carei Plain raises question marks for their survival. Measures to limit the impact of invasive species are needed. The common ragweed alone isn't only damaging the sand dunes, but the agricultural fields, too, being harmful for human health (see in: Bohren et al. 2006, Hodisan et al. 2008, Pinke et al. 2011). However, important measures are very difficult to take given the economic situation. What can be done, though, with minimum effort and resources is to identify the most natural and least affected zones from the area and to protect them accordingly. In the case of these zones, even if done manually, the spreading of the most dangerous invasive species like the ragweed can be stopped, since many species do come back after the removal of the invasive plants (Baider & Florens 2011). Using herbicides is prohibited in a protected area due to the impact on local species, so it is recommended the control over this species with selective measures and keeping in mind conservational aspects (Pinke et al. 2011). Thus, the first step would be to identify the least affected natural habitats and to conserve them as they are, while the control over the alien plants must be done depending on local conditions (Juami & Tyvönen 2012).

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